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Ticks (Ixodidae) on Birds Migrating from Europe and Asia to Africa, 1959-61*

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The need for imaginative thinking and research in the epidemiology of diseases transmitted by arthropods is made manifest by new views of the longevity and host ranges of arthropod-borne viruses, as well as by other biological and medical phenomena. Among these is the intercontinental transport of ticks by migrating birds. During the fall migration periods of 1959, 1960 and 1961, 32 086 birds (comprising 72 forms) were examined for ticks in Egypt while en route *from Asia and eastern Europe to tropical Africa. Of these, 40 forms, represented by 31 434 birds, were tick-infested. The bird hosts, numbering 1040 (3.31 % of the tick-infested bird forms examined), bore 1761 ticks, or 1.69 ticks per host. Common ticks taken were* Hyalomma m. marginatum, Haemaphysalis punctata, *and* Ixodes ricinus. Ixodes frontalis *and* Hyalomma aegyptium *were less common and* Haemaphysalis sulcata, H. otophila, *and* H. pavlovskyi *were rare. The common tick species are known to be reservoirs and vectors of pathogens causing a number of human and animal diseases in Europe and Asia. Several of the bird hosts have also been incriminated as reservoirs in their summer ranges. Over 20 strains of pathogenic viruses were isolated from these birds and their ticks in Egypt in the 1961 fall migration period.*

The most difficult problems in investigations such as this in many parts of the world are taxonomic ones : the correct identification of bird hosts, of immature stages of ticks and of viruses.

INTRODUCTION

Recently in this *Bulletin* we presented a report on ticks taken from birds in Egypt, mostly near Cairo, during the spring, northward migration periods from 1955 through 1960 (Hoogstraal et al., 1961). The present study summarizes data for ticks taken from birds going in the opposite direction—southwards—during the fall migration periods of 1959, 1960 and 1961. All of these birds were examined on the Mediterranean coast between Port Said and Mersa Matruh. Spring and fall migration patterns through Egypt are quite distinct. The numbers, kinds of species, and rates of tick infestation differ in each of these seasons, and annual fluctuations possibly also occur.

The tick species carried into Africa during the fall migration are endemic in Europe and Asia, while those carried into Europe and Asia during the spring migration are endemic in tropical Africa. We have considerable circumstantial evidence to suggest that some of these Palearctic and Ethiopian tick forms may interbreed in marginal areas as a result of introductions from migratory birds, and are studying this possibility experimentally at the present time.

Characteristics of migration patterns described for each host species have been derived from the most up-to-date ornithological literature on the subject, and a map of the winter and summer range of each

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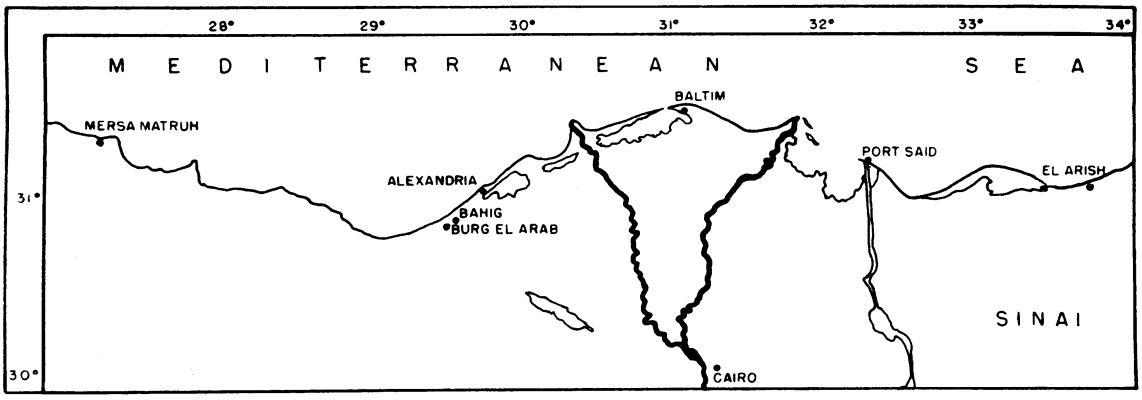
FIG. 1

COLLECTING LOCALITIES MENTIONED IN TEXT AND CAIRO AND ALEXANDRIA



is included. For those species that have already been so treated in our report on tick-infested spring migrants in Egypt (Hoogstraal et al., 1961) the reader is referred to the pertinent page and figure of the earlier paper. Some observations on numbers of migrants in specific areas of Egypt are also included. Where a species is said to be common but only a few specimens were examined, the reader might suspect a discrepancy. These differences, however, are due to the impossibility of capturing some species alive by the methods we used.

Many of the birds and the ticks reported herein originate in areas of eastern Europe and in the USSR, where a variety of viruses and rickettsiae causing human diseases are known to infect both these birds and their tick parasites. It is, therefore, especially noteworthy that over 20 strains of viruses pathogenic for laboratory mice have been isolated from some of the birds and ticks collected during the 1961 migration period. These viruses will be reported separately by Dr Jack Schmidt of the Virology Department of the United States Naval Medical Research Unit, No. 3 (NAMRU-3).

The results are summarized in Table 2 (see page 254), while the details for each of the three years 1959, 1960 and 1961 are given in Appendix Tables 1-3. The localities in which most of these collections were made and dates spent at each place are listed in Table 1. In addition to these periods, a few collections were made in November and early December of each year. Collecting localities are noted in the accompanying map (Fig. 1) of northern Egypt.

The nomenclature of birds is that of Peters (1931-48) for the non-Passeriformes and of Vaurie (1959) for the Passeriformes. Europe is arbitrarily divided into eastern and western portions at the 12° meridian.

Certain differences will be found between the present report and that of Hoogstraal & Kaiser (1961) in the species designations of some important bird hosts (*Phylloscopus trochilus* subspp.) and of immature stages of *Ixodes* spp. These changes, the result of intensive studies over a three- to five-year period by several outstanding specialists, point to the fact that taxonomic problems in many parts of the world are the most difficult ones in any research such as this. The accuracy of epidemiological evidence and of the conclusions from these investigations depends entirely on the accuracy of identification of the ticks, the hosts and the pathogens.

BIRD HOSTS

FAMILY FALCONIDAE (FALCONS)

Falco naumanni Fleisher. Lesser Kestrel. (See p. 198 and Fig. 2 of Hoogstraal et al., 1961, for range).

This is a rare migrant in Egypt in autumn. The only individual seen in three years' collecting, near Mersa Matruh on 26 September 1960, was infested by one immature *Hyalomma* sp.

FAMILY PHASIANIDAE (QUAIL AND PHEASANTS)

Coturnix coturnix coturnix (Linnaeus). European Quail. (See p. 200 and Fig. 4 of Hoogstraal et al., 1961, for range.)

Quail arrive on the coasts of Egypt in autumn in enormous numbers. Banding returns suggest that the majority of these birds come from the Ukraine and the Caucasus in the southern USSR.

The rates of infestation of European quail recorded at different times and localities during this study are summarized in Table 1.

Quail were hosts of approximately one-third of the total of 1761 ticks taken during this three-year survey. These birds are easily captured and examined, and, in addition to those obtained by our own collecting resources, numerous quail collected by others for sale were searched for ticks. Therefore in this study quail possibly appear to play a disproportionately greater role as tick hosts than they actually do in nature, in comparison with certain other bird species.

A large number of quail examined at Port Said had been collected commercially near El Arish (see Fig. 1) and held some days on Arab dhows before being delivered to Port Said. Undoubtedly, many of rhese birds had lost some or all of their ticks in the interval, and the prevalence and rate of infestation tecorded from Port Said thus do not represent true levels of tick infestation of quail arriving in eastern Egypt. Quail from all other localities were collected by NAMRU-3 personnel, often with the assistance of local Bedouin, and were immediately examined for ticks. In 1959, many ticks from quail at all localities visited were lost owing to improperly developed techniques for holding large numbers of tick-infested birds. In 1961, in spite of precautions, 13 of 139 quail found tick-infested at Burg El Arab were free of ticks when examined in the laboratory.

The 645 ticks taken from quail were: 10 *Ixodes* sp., four *I. frontalis*, two *I. ricinus*; 416 *Haemaphysalis punctata*, one *H. pavlovskyi*, two *H. otophila*; 11 *Hyalomma* sp., 63 *H. aegyptium*, and 136 *H. m. marginatum*. Quail were hosts of 63 (84%) of the 75 *Hyalomma aegyptium* and 416 (84%) of the 495 *Haemaphysalis punctata* taken from all birds during this study, but of only 136 (20%) of the 686 *Hyalomma m. marginatum*. These three tick species were found on quail in each collecting locality. Of 16 061 quail inspected, 491 (3.05%) were infested.

The prevalence of infestation was less in October than in September. At Port Said it was 2.94% (1959) and 3.28% (1960) in September, but only 0.22% (1959) and 0.52% (1961) in October. For reasons noted above, data from Burg El Arab were more truly representative of infestation than those from Port Said. Prevalences at Burg El Arab were 6.90%

TABLE 1

PREVALENCE OF TICK INFESTATION OF EUROPEAN QUAIL (*COTURNIX C. COTURNIX*) DURING THE AUTUMN MIGRATION AT DIFFERENT LOCALITIES AND TIMES IN EGYPT

Year	September					October					Total		
	Dates	Locality	No. exam.	Infested		Dates	Locality	No. exam.	Infested		No. exam.	Infested	
				No.	%				No.	%		No.	%
1959	3-11	Port Said	1 051	31	2.94	3-11	Port Said	881	2	0.22			
	14-29	Mersa Matruh	1 657	49	2.95	14-19	Baltim	234	1	0.42	4 431	125[a]	2.82[a]
	15-25	Burg El Arab (Bahig)	608	42	6.90								
1960	10-29	Burg El Arab (Bahig)	1 318	114	8.64	5-11	Burg El Arab (Bahig)	574	17	2.96			
	8-9	Port Said	1 611	53	3.28						4 190	203	4.84
	23-29	Mersa Matruh	687	19	2.76								
1961	12-28	Burg El Arab (Bahig)	2 896	139[b]	4.79[b]	3-18	Port Said	4 544	24	0.52	7 440	163[b]	2.19[b]
Total			9 828	447	4.55			6 233	44	0.70	16 061	491	3.01

[a] Numerous ticks were lost from quail in 1959.
[b] Ticks lost from 13 birds while *en route* to laboratory.

(1959), 8.64% (1960), and 4.79% (1961) in September, and 2.96% (1960) in October.

The low prevalence of infestation at Mersa Matruh (2.95% in 1959, 2.76% in 1960) in comparison with that in Burg El Arab (6.90% in 1959, 8.64% in 1960) during essentially the same periods of September is noteworthy and may indicate a geographical difference in tick-infestation of quail.

Differences in Burg El Arab September averages for 1959 (6.90%), 1960 (8.64%), and 1961 (4.79%) suggest rather slight variation in infestation prevalence during these years.

FAMILY COLUMBIDAE (PIGEONS AND DOVES)

Streptopelia turtur turtur (Linnaeus). Turtle dove. (See p. 200 and Fig. 5 of Hoogstraal et al., 1961, for range.)

The nominate race from Europe and the western USSR is much more common during autumn migration than the eastern race *arenicola*. The three infested birds taken in 1961 were all *turtur*.

A total of 1237 turtle doves of both subspecies was examined. In 1959 and 1960, 787 doves from Port Said, Burg El Arab, and Mersa Matruh were uninfested. In 1961, a single *Ixodes* sp. was taken from one of 158 doves examined at Port Said in October and two immature *Hyalomma aegyptium* and one immature *H. m. marginatum* were found on two of 292 doves examined at Burg El Arab in September.

Light tick infestation of doves has been observed in several parts of the world and we postulate that this may be due to the open areas in which these ground-feeding birds often alight.

FAMILY CUCULIDAE (CUCKOOS)

Cuculus canorus canorus Linnaeus. European Cuckoo. Fig. 2.

The European cuckoo breeds throughout Europe (except in Spain), and in the USSR and northern Asia. It winters south of its breeding range, and is found in most of Africa south of the Sahara. It is common on both migrations in Egypt, the fall migration beginning in mid-August and lasting through September. The fall migration of cuckoos is usually to the south or south-east so that migrants arriving in Egypt probably come from eastern Europe or the western USSR.

Forty-seven birds were seen in the periods between 3 September and 4 October. In 1959, 20 cuckoos were examined; one at Mersa Matruh bore a single *Hyalomma m. marginatum*. In 1960, none of 24 birds was infested. Only three were taken in 1961, all at Burg El Arab; one of these yielded three *Ixodes* sp.

FAMILY STRIGIDAE (OWLS)

Otus scops scops (Linnaeus). Scops Owl. Fig. 3.

The scops owl breeds in southern and south-eastern Europe, western USSR, and possibly the Near East. It winters in northern tropical Africa. Although common on spring migration in Egypt, the five specimens recorded here are the only fall migrants known to have been taken in Egypt. These owls presumably come from the Balkans or western USSR.

Three of five scops owls were carrying a total of 10 *Hyalomma m. marginatum*. All birds were seen in September and all at Burg El Arab, except for a single uninfested one from Mersa Matruh in 1959.

FAMILY MEROPIDAE (BEE-EATERS)

Merops apiaster Linnaeus. European Bee-eater. Fig. 4.

This bee-eater breeds across southern Europe and USSR, and into south-west Asia, and winters in India and Africa south of the Sahara. It is common on both migrations in Egypt.

One of four European bee-eaters at Burg El Arab in September 1959 yielded a single *Hyalomma m. marginatum*; another at the same locality on 26 September 1961 was uninfested.

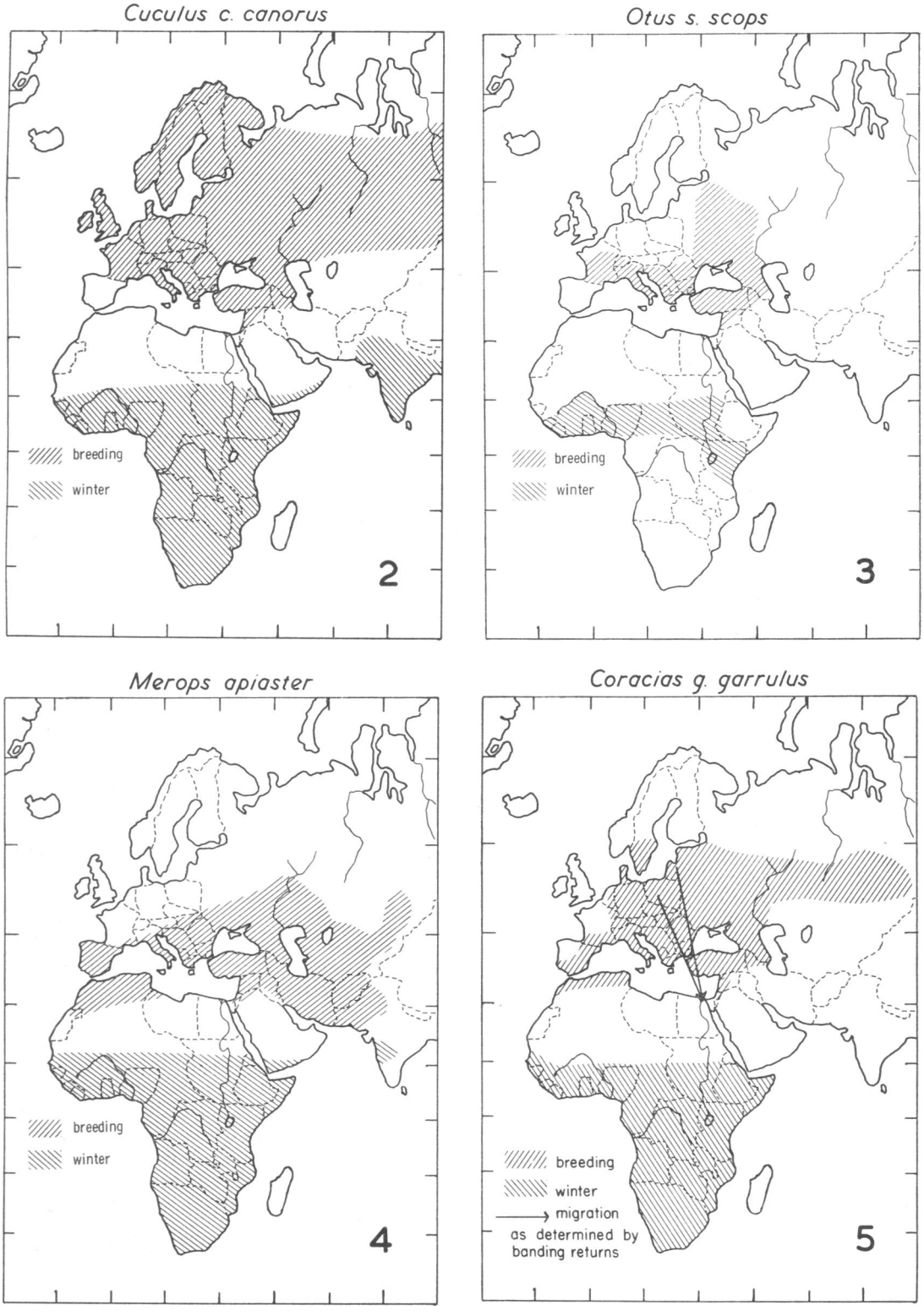
FAMILY CORACIIDAE (ROLLERS)

Coracias garrulus garrulus Linnaeus. European Roller. Fig. 5.

The roller breeds in much of Europe, the USSR, and western Asia, and winters in Africa south of the Sahara. In Egypt it is a rare spring migrant but it is common in autumn. In the latter period, the majority pass through Egypt between mid-August and late September on their way from eastern Europe. Three recoveries in Egypt were of birds banded at Łodz in western Poland and Riga on the Baltic.

Fifty-three European rollers were examined at Port Said, Burg El Arab, and Mersa Matruh, all in September. One of these, at Mersa Matruh in 1959, bore one *Hyalomma* sp. Thirty-six birds were seen in 1959, three in 1960, and 14 in 1961.

FIG. 2-5. WINTER AND SUMMER RANGE OF TICK HOSTS



FAMILY PICIDAE (WOODPECKERS AND WRYNECKS)

Jynx torquilla torquilla Linnaeus. Wryneck. Fig. 6.

The nominate race of the wryneck breeds across most of Europe and European USSR to about the Urals, and winters in the northern half of Africa. It occurs commonly in Egypt on both migrations, and in the autumn usually appears between early September and early October. Banding returns show that birds breeding in eastern Europe migrate to the south-west; therefore birds passing through Egypt probably come from the USSR.

One of 43 wrynecks was infested by three *Hyalomma* sp. at Mersa Matruh in September 1959. These birds were also seen at Port Said and Burg El Arab: 12 in 1959, 11 in 1960, and 20 in 1961. At the latter locality in 1961, two wrynecks bore moulted skins of immature ticks; these birds were not recorded as actually infested.

FAMILY ORIOLIDAE (ORIOLES)

Oriolus oriolus oriolus (Linnaeus). Golden Oriole. Fig. 7.

The golden oriole breeds across most of Europe and the USSR into western Asia, and winters in Africa south of the Sahara, most commonly in east and south Africa. Common on both passages in Egypt, the height of this bird's fall migration occurs in mid-September. Golden orioles breeding in Europe tend to migrate to the south-east in the fall. From banding recoveries it appears that those from eastern Europe pass through Egypt.

Eleven of 466 golden orioles, all seen in September at each collecting locality, were infested. In 1959, three of 102 birds bore three *Hyalomma m. marginatum* and in 1960, eight of 258 bore two *Ixodes ricinus*, two *Hyalomma* sp., and 16 *H. m. marginatum*. None of 106 orioles was infested in 1961.

FAMILY TURDIDAE (THRUSHES AND CHATS)

Saxicola rubetra (Linnaeus). Whinchat. Fig. 8.

The whinchat breeds across Europe and the USSR to western Asia, and winters in northern tropical Africa. It is common in Egypt on both passages, arriving in the fall between late August and late October. Little is known of the migration routes of the whinchat, but presumably Egyptian migrants come from the USSR.

Seventeen infested whinchats were found among the 506 examined at all localities. Nine out of 217 in 1959 yielded one *Ixodes ricinus*, three *Haemaphysalis punctata*, and 12 *Hyalomma* sp. None of 58 in 1960 was infested, but in 1961 eight of 231 bore 12 *Hyalomma m. marginatum*.

Saxicola torquata rubicola (Linnaeus). Stonechat. Fig. 9.

The stonechat breeds in western and southern Europe east to southern USSR and Turkey. It is only partially migratory, some birds remaining in the southern part of their breeding range and others wintering south to Upper Egypt from late October to mid-March. Stonechats wintering in Egypt probably come from the northern part of the breeding range, from eastern Europe and the Ukraine.

Seven stonechats were taken at Port Said in October 1961. Two of these were infested by one female *Ixodes frontalis* and one *Hyalomma m. marginatum*.

Oenanthe oenanthe oenanthe (Linnaeus). Wheatear. (See p. 202 and Fig. 9 of Hoogstraal et al., 1961, for range.)

Since the entire population of this race, even from eastern Siberia, winters in tropical Africa, wheatears reaching Egypt probably come from the USSR and western Asia.

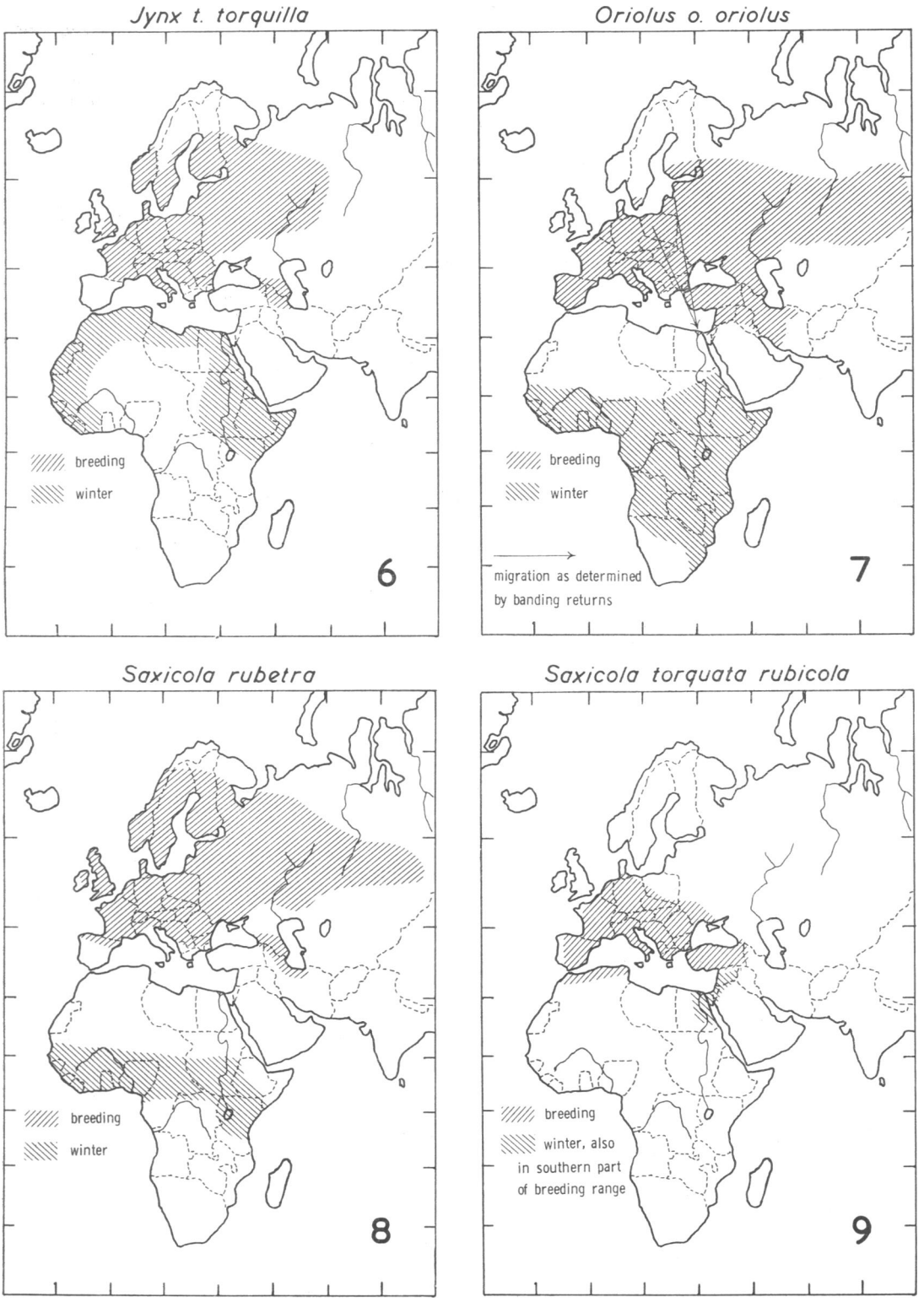
Ten of the 226 wheatears examined were infested by three *Haemaphysalis punctata*, one *H. sulcata*, six *Hyalomma* sp., one *H. aegyptium*, and 14 *H. m. marginatum*. All infested birds were from Mersa Matruh in September of 1959 and 1960. In October 1961, 54 wheatears at Port Said were free of ticks. We have not seen this bird at Burg El Arab, but it was common at Mersa Matruh and Port Said during fall migration periods.

Oenanthe isabellina (Temminck). Isabelline Wheatear. (See p. 202 and Fig. 10 of Hoogstraal et al., 1961, for range.)

Birds passing through Egypt in the autumn probably come from the western portion of the breeding range, the Near East and the Caucasus.

Five of the 116 isabelline wheatears examined were carrying one *Haemaphysalis sulcata*, four *Hyalomma* sp., one *H. aegyptium*, and one *H. m. marginatum*. Two hosts were from Mersa Matruh and three from Port Said. In 1959 and 1960, 28 isabelline wheatears seen at Burg El Arab were free of ticks. In 1961, seven examined at Port Said in October also lacked ticks.

FIG. 6-9. WINTER AND SUMMER RANGE OF TICK HOSTS



Monticola saxatilis (Linnaeus). Rock Thrush. (See p. 202 and Fig. 8 of Hoogstraal et al., 1961, for range.)

The rock thrush is much less common in autumn than in spring. Migration is generally south-west, since the entire species winters in Africa. Birds reaching Egypt probably come from southern USSR and the Near East.

Only 10 rock thrushes were seen. One of these, at Port Said in September 1959, bore 10 *Hyalomma m. marginatum* and another at Burg El Arab in September 1960 had three *H. m. marginatum*. In 1961, seven uninfested birds were taken at Burg El Arab and Port Said.

Phoenicurus phoenicurus phoenicurus (Linnaeus). Common Redstart. (See p. 204 and Fig. 13 of Hoogstraal et al., 1961, for range.)

The fall migration of all redstarts is to the south-west, and those arriving in Egypt probably come from the USSR and western Asia.

The redstart is not only common but easily captured, and 84 of the 1253 birds taken were tick-infested. The 132 parasites were 13 *Ixodes* sp., seven *Haemaphysalis punctata*, one *Hyalomma* sp., two *H. aegyptium*, and 109 *H. m. marginatum*.

Luscinia luscinia (Linnaeus). Thrush Nightingale. Fig. 10.

The thrush nightingale breeds from the shores of the Baltic south to Romania and east to central Asia; it winters in East Africa. In Egypt it is fairly common in autumn but less so in spring. *L. luscinia* has not been recorded on the south shore of the Mediterranean west of Mersa Matruh; therefore birds from eastern Europe and the USSR probably pass through Egypt. This assumption is supported by the recovery in Egypt of a bird banded in Sweden.

L. luscinia and *L. m. megarhynchos* were seen at Mersa Matruh and Burg El Arab but not at Port Said. In 1959, study skins were made of tick-infested *Luscinia* and only these were identified to species. Non-infested nightingales in 1959 were listed as *Luscinia* sp. Nine *L. luscinia* bore 10 *Ixodes* sp., nine *I. ricinus*, one *Haemaphysalis punctata*, and two *Hyalomma m. marginatum*. In 1960 and 1961, all nightingales could be field-identified and it was established that, with an infestation prevalence of over 20%, *L. luscinia* was one of the most commonly tick-infested birds encountered in significant numbers and that it was an especially important host of *Ixodes ricinus*. During 1960 and 1961, 14 *Ixodes* sp., 109 *I. ricinus*, six *Haemaphysalis punctata*, one *H. sulcata*, three *Hyalomma* sp., and 14 *H. m. marginatum* were recovered from 61 of the 278 *L. luscinia* examined. Approximately two ticks occurred on each host.

Luscinia megarhynchos megarhynchos Brehm. Nightingale. Fig. 11.

The nightingale breeds from western Europe to the Ukraine and Asia Minor, and winters in northern tropical Africa. In Egypt it is more common in spring than in fall, although occasional large fall flights have been observed. Nightingales reaching Egypt probably come from eastern Europe. Those breeding in central and western Europe have been shown by banding records to migrate to the south-west.

See *L. luscinia* above for remarks on 1959 collections of both species. The three hosts known to be *L. m. megarhynchos* in 1959 bore one specimen each of *Ixodes ricinus*, *Haemaphysalis punctata*, and *Hyalomma m. marginatum*. In 1960 and 1961, the 15 infested nightingales of this species, out of 138 examined, yielded five *Ixodes* sp., 33 *I. ricinus*, one *Haemaphysalis punctata*, one *Hyalomma* sp., and eight *H. m. marginatum*. Thus, the pattern of tick species on both kinds of nightingales is quite similar, though the over-all prevalence and rate of infestation may be lower in *L. m. megarhynchos* than in *L. luscinia*. In 1960, the prevalence of infestation of *L. m. megarhynchos* was quite low, though the rate of infestation per host was high; in 1961 the prevalence was high and the rate moderate.

FAMILY SYLVIIDAE (WARBLERS)

Acrocephalus schoenobaenus (Linnaeus). Sedge Warbler. Fig. 12.

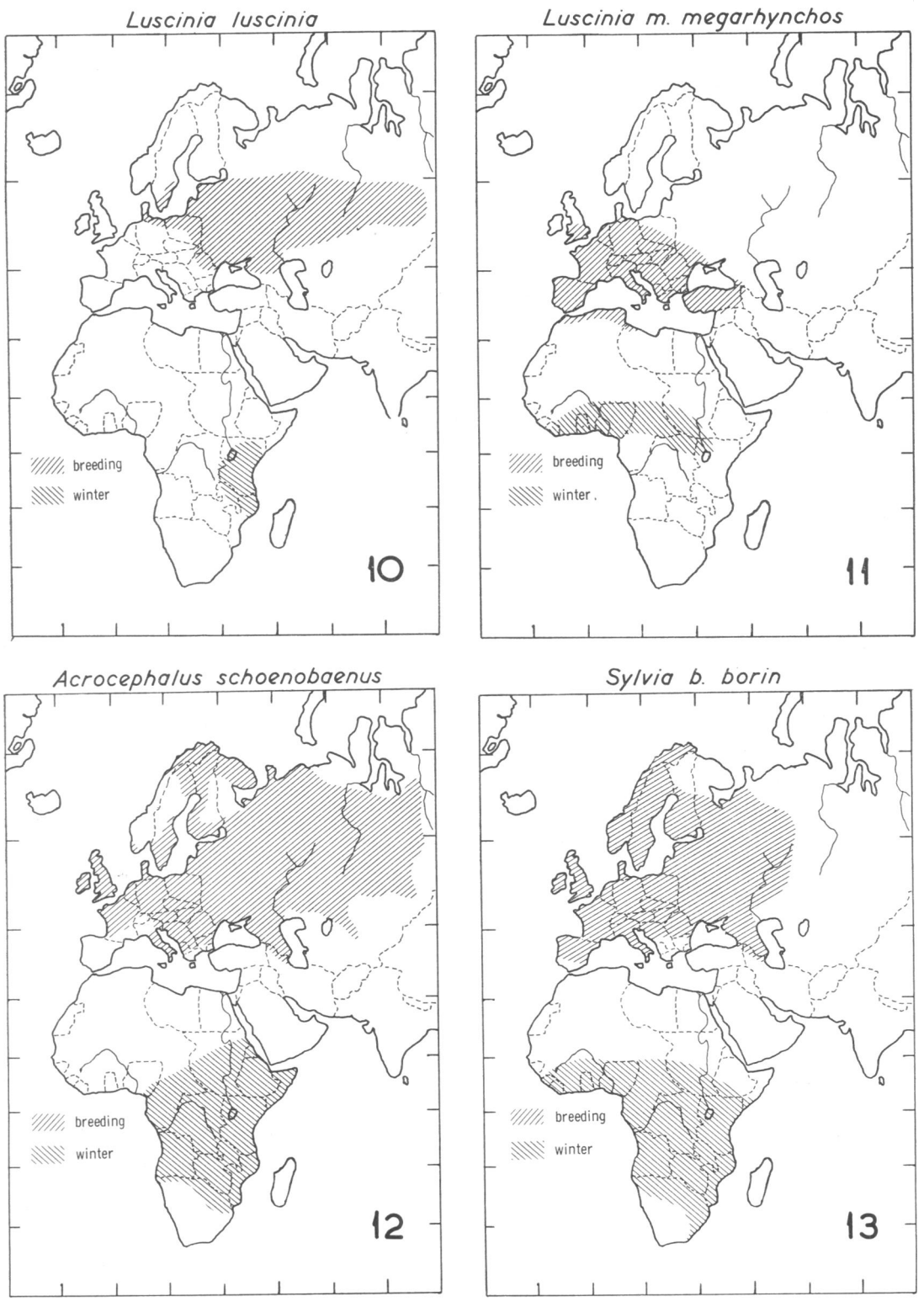
The sedge warbler breeds from western Europe to central Asia, and winters throughout most of tropical Africa. In Egypt it is common on both passages, the fall migration reaching its peak in late September.

A single Sedge Warbler of 138 examined was infested by seven *Haemaphysalis punctata*; this host was taken at Port Said in October 1961.

Sylvia borin borin (Boddaert). Garden Warbler. Fig. 13.

The garden warbler breeds from Europe east to about the Urals, and winters in tropical Africa. It occurs in approximately equal numbers on spring

FIG. 10-13. WINTER AND SUMMER RANGE OF TICK HOSTS



and autumn passage in Egypt, but is never common. Banding data suggest that birds reaching Egypt in autumn come from south-eastern Europe.

Only three of 166 garden warblers were infested. Each bore a single *Hyalomma m. marginatum*.

Sylvia atricapilla atricapilla (Linnaeus). Blackcap. Fig. 14.

The blackcap breeds from Europe east to Asia Minor and the Urals, and winters from the southern part of its breeding range south to northern tropical Africa. Meinertzhagen (1930) stated that blackcaps "abound" in Egypt on both passages. However, they were quite rare during the three years that we have been collecting in autumn and are the least common of the four species of *Sylvia* that have been identified as tick hosts.

At Burg El Arab in September 1961, one blackcap bore two *Hyalomma m. marginatum*. Seventeen others seen at Burg El Arab and Mersa Matruh during this study were uninfested.

Sylvia communis communis Latham. Whitethroat. Fig. 15.

The whitethroat breeds in Europe and western USSR and winters over much of tropical Africa. It is common on both passages in Egypt. Meinertzhagen (1930) stated that the eastern race *icterops*, which breeds from the Near East to Russian Turkestan, is almost as abundant as the nominate *communis*. However, all specimens that we have examined appear to be *communis*, the western race.

Five out of 1134 whitethroats examined bore two *Ixodes* sp., one *I. frontalis*, 12 *I. ricinus*, one *Hyalomma* sp., and two *H. m. marginatum*.

Sylvia curruca curruca (Linnaeus). Lesser Whitethroat. Fig. 16.

The lesser whitethroat breeds from Europe east to Iran and western Siberia, and winters in northern tropical Africa. It is common on both passages in Egypt. In this species practically the entire European population moves to the south-east in autumn, passing into Africa over or around the eastern end of the Mediterranean. Egyptian specimens, therefore, probably originate in western or central Europe.

Four of 904 lesser whitethroats examined yielded one *Ixodes ricinus* and four *Hyalomma m. marginatum*.

Phylloscopus trochilus (Linnaeus). Willow Warbler. Fig. 17.

Two subspecies of the willow warbler pass through Egypt, the nominate *trochilus* from western and central Europe and *acredula* from northern and eastern Europe and the USSR east to western Siberia. Both forms are much more abundant in autumn than in spring. There is, in fact, only one spring record from the Nile Delta. Among birds reaching Egypt in the fall there is a surprising preponderance of the western form, *trochilus*, although the form breeding directly to the north of the Delta is *acredula*. Field identification of willow warblers to subspecies proved impossible. Of the long series of study skins of willow warblers examined, about 50% were *trochilus*, 40% intermediate, and 10% *acredula*. This suggests that Egyptian migrants come primarily from eastern Germany and Poland, and possibly from Scandinavia. Willow warblers from western Europe are known to migrate to the south-west.

Of 6283 of these birds examined, 226 were infested by 87 *Ixodes* sp., 33 *I. frontalis*, 20 *I. ricinus*, 37 *Haemaphysalis punctata*, two *H. pavlovskyi*, 53 *Hyalomma* sp., four *H. aegyptium*, and 180 *H. m. marginatum*. The prevalence of infestation ranged from 2.28% to 8.51% of the willow warblers taken, and the number of ticks per infested bird from 1.6 to 2.0.

Phylloscopus collybita (Vieillot). Chiffchaff. Fig. 18.

Two subspecies of chiffchaff are recorded from Egypt, *collybita* from western, central, and southern Europe, and *abietinus* from northern and eastern Europe, the USSR, and possibly Asia Minor. Populations in northern Germany and Poland are intergrades. Both forms winter commonly in Egypt. It is remarkable that only one specimen has been taken on fall migration; this suggests that most chiffchaffs fly over the coast and land further inland. The single bird collected is intermediate between *collybita* and *abietinus* and may have originated in northern Germany or Poland.[1]

This chiffchaff, collected at Port Said on 7 November 1959, was carrying one *Ixodes frontalis* and one *Hyalomma m. marginatum*. The former tick species may have attached to this bird in its summer range, the latter further south while the host was migrating.

[1] There is also a record of *P. collybita* banded in Schleswig and recovered at Mersa Matruh.

FIG. 14-17. WINTER AND SUMMER RANGE OF TICK HOSTS

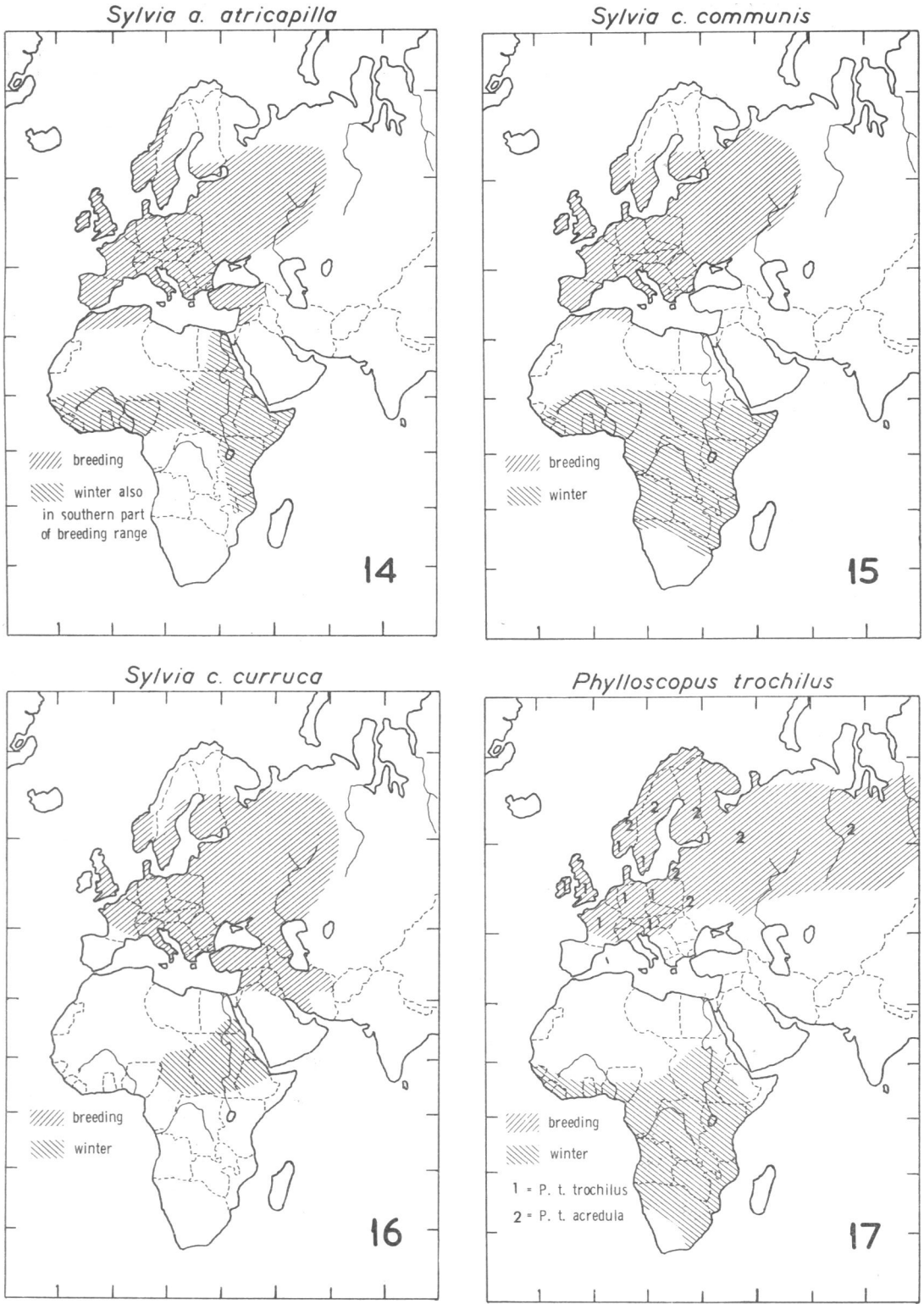
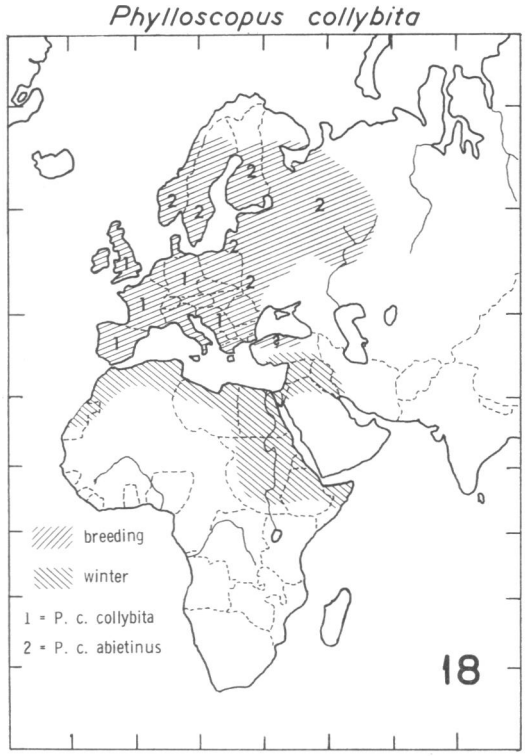
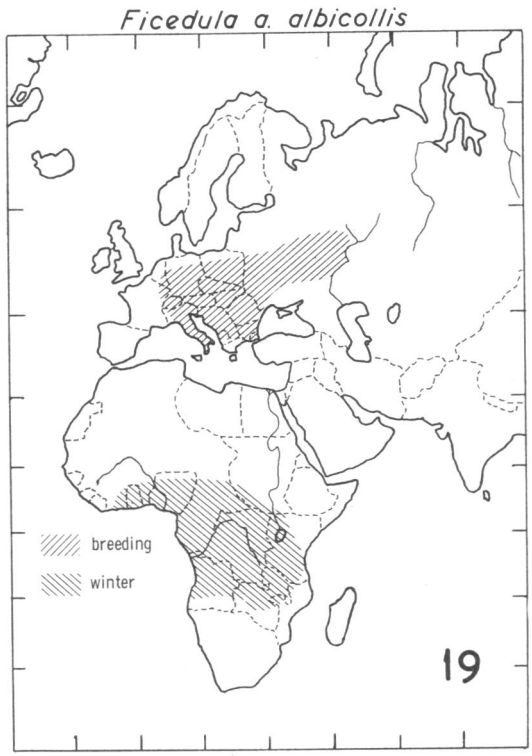
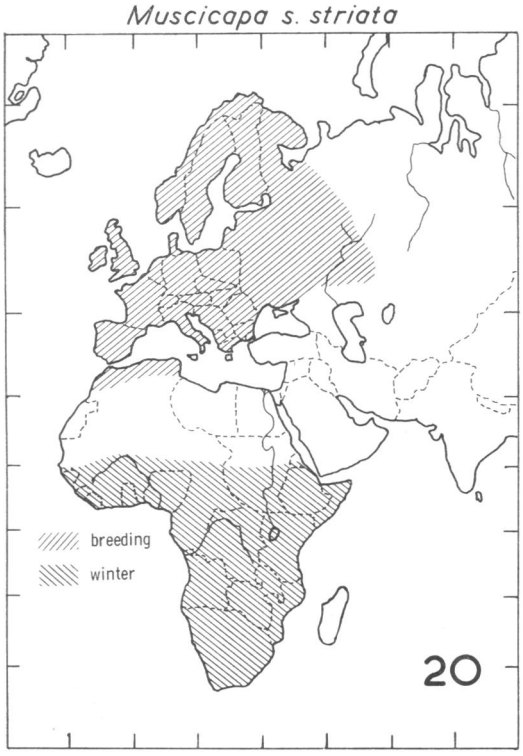


FIG. 18-21. WINTER AND SUMMER RANGE OF TICK HOSTS







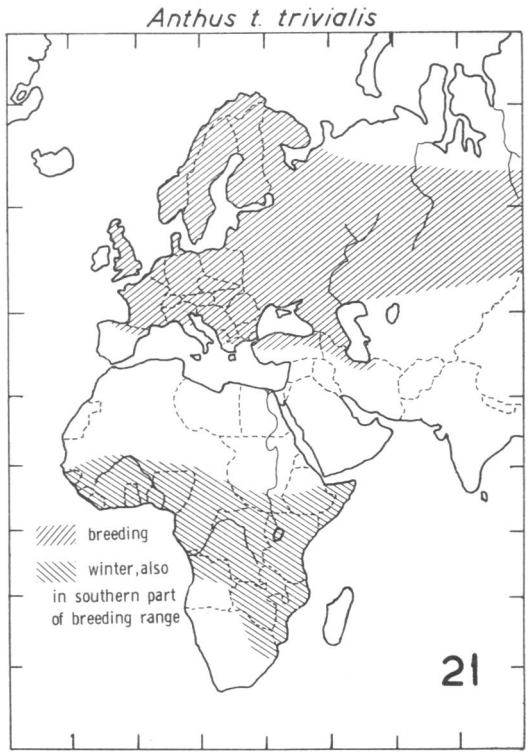
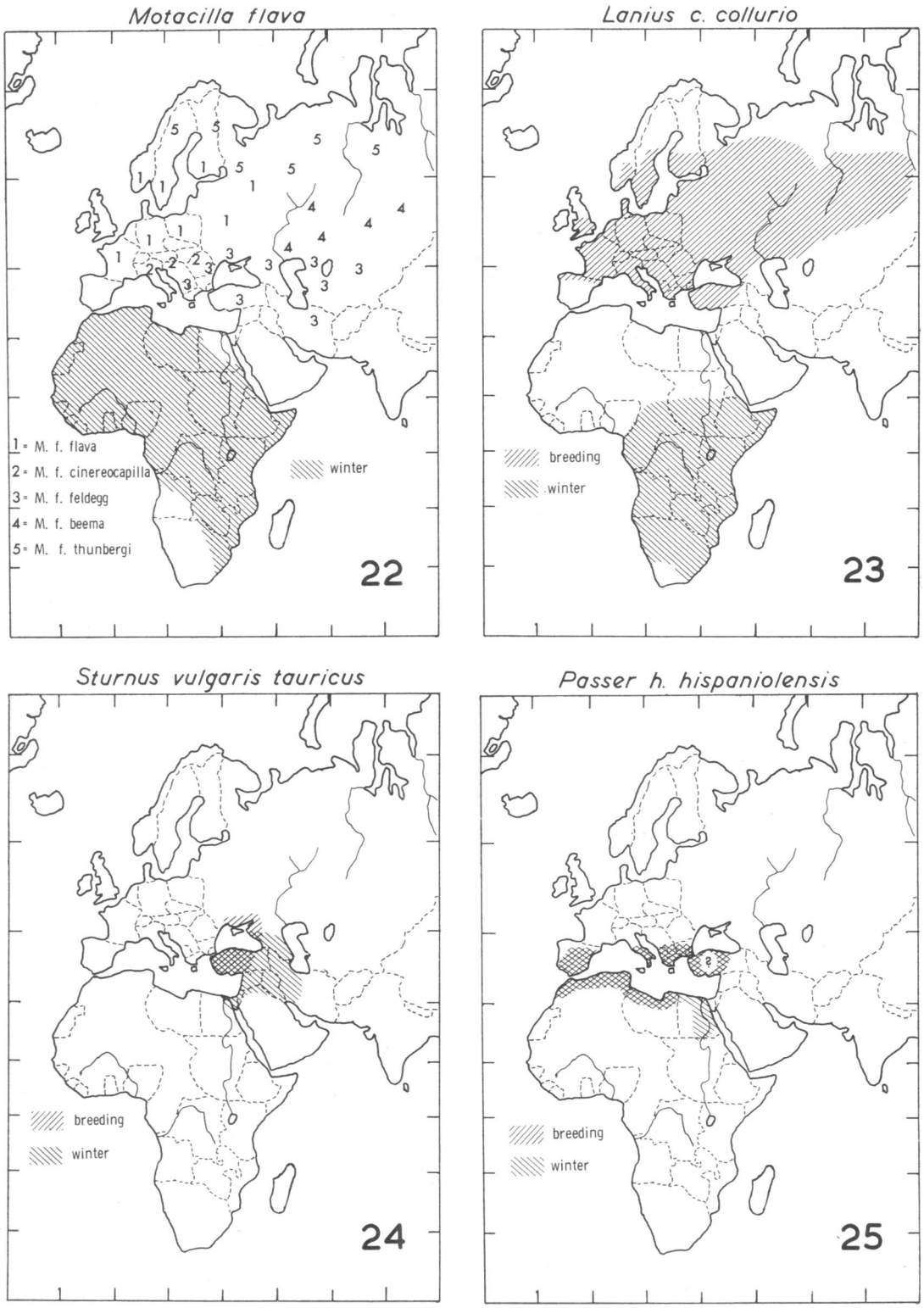


FIG. 22-25. WINTER AND SUMMER RANGE OF TICK HOSTS



FAMILY MUSCICAPIDAE (FLYCATCHERS)

Ficedula albicollis albicollis (Temminck). Collared Flycatcher. Fig. 19.

The collared flycatcher breeds from central and south-eastern Europe to central USSR, and winters in tropical Africa. Although common in Egypt in spring migration, the eight specimens reported here are the only fall migrants recorded from Egypt.

Eight collared flycatchers were collected at Mersa Matruh and Burg El Arab in September and October of 1960 and 1961. Two of these at Burg El Arab, in September of each year, bore a total of three ticks, two *Hyalomma* sp. and one *H. m. marginatum.*

Muscicapa striata striata (Pallas). Spotted Flycatcher. Fig. 20.

The spotted flycatcher breeds throughout Europe and the USSR east to western Siberia, and winters in Africa south to the Cape. Birds from the Balkans are said to be paler and more like the eastern race *neumanni.* This bird is common on both migrations in Egypt. Spotted flycatchers taken in Egypt on fall migration are all of the nominate race, although some are paler than typical specimens. They probably came from eastern and south-eastern Europe.

Twenty-four of the 590 spotted flycatchers examined were infested by 35 ticks, consisting of three *Ixodes* sp., three *I. frontalis,* nine *Haemaphysalis punctata,* one *Hyalomma* sp., and 19 *H. m. marginatum.* Tick hosts were taken at each of our chief collecting localities. The ticks reported above were taken from 22 hosts; those from two other hosts were lost in transit.

FAMILY MOTACILLIDAE (WAGTAILS AND PIPITS)

Anthus campestris campestris (Linnaeus). Tawny Pipit. (See p. 206 and Fig. 18 of Hoogstraal et al., 1961, for range.)

Nothing is known of the migration routes of the tawny pipit.

Nine of the 18 tawny pipits seen were infested. Their 29 ticks were two *Ixodes* sp., seven *I. ricinus,* one *Haemaphysalis punctata,* three *Hyalomma* sp., and 16 *H. m. marginatum.* All hosts were taken in September, eight at Burg El Arab and one at Mersa Matruh.

Anthus trivialis trivialis (Linnaeus). Tree Pipit. Fig. 21.

The tree pipit breeds from Europe to Siberia, and winters in the southern part of its breeding range and throughout tropical Africa. It is common on both passages in Egypt. Banding returns show that the majority of German birds migrate due south, therefore those reaching Egypt probably come from the USSR.

Fifty-six tree pipits were taken; nine of these carried 84 ticks, consisting of 12 *Haemaphysalis punctata,* two *Hyalomma* sp., one *H. aegyptium,* and 69 *H. m. marginatum.* Infested birds were captured at Port Said and Burg El Arab during September and October. Although not a large number of tree pipits was taken, this bird is quite possibly an important carrier of ticks during the fall migration.

Motacilla flava Linnaeus. Yellow Wagtail. Fig. 22.

The yellow wagtail breeds in numerous races through the Palearctic Faunal Region, and winters in tropical regions to the south. Several races reach Africa. The two forms most commonly found in Egypt are the nominate race *flava,* from central Europe and USSR, and *feldegg,* from the Balkans through southern USSR and Asia Minor to Afghanistan.

The single infested yellow wagtail examined, a female of indeterminate race at Mersa Matruh in September 1959, was infested by one *Haemaphysalis sulcata* and one *Hyalomma m. marginatum.*

Motacilla alba alba Linnaeus. White Wagtail. (See p. 206 and Fig. 16 of Hoogstraal et al., 1961, for range.)

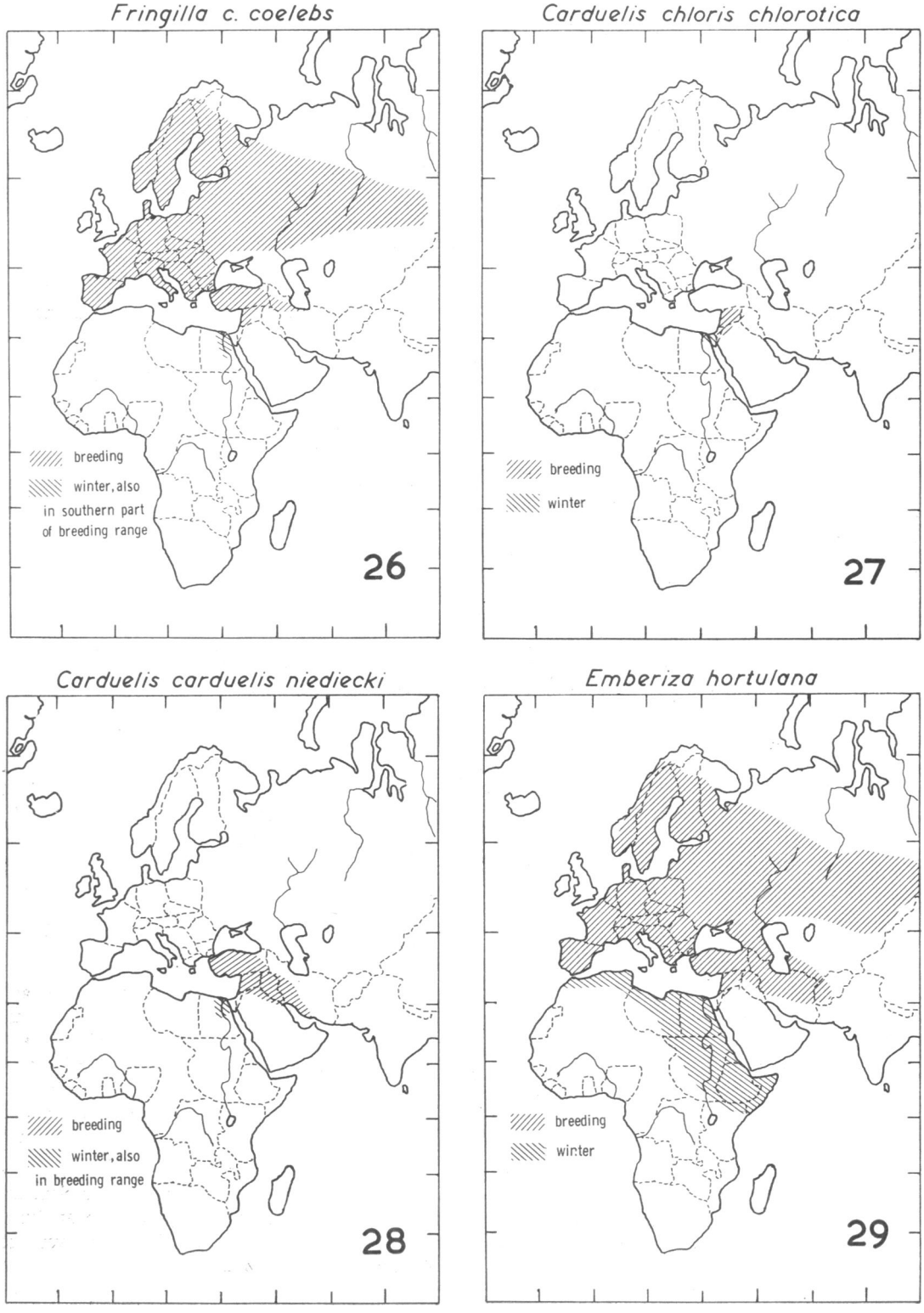
Thirty-four white wagtails at Port Said in October 1959 were uninfested but one of nine examined there during the same month in 1961 yielded one *Hyalomma m. marginatum.*

FAMILY LANIIDAE (SHRIKES)

Lanius collurio collurio Linnaeus. Red-backed Shrike. Fig. 23.

The red-backed shrike breeds from Europe to western Siberia and winters in eastern and southern Africa. It is abundant in Egypt in the fall. In the spring the main passage is east of Suez and this bird is practically unknown in the Nile Delta. The fall migration of red-backed shrikes is generally south-east, and those reaching Egypt probably come from central and eastern Europe. More remarkable is the spring migration, in which the entire European population migrates around the eastern end of the Mediterranean and north of the Aegean, then turns west to breeding grounds in western Europe.

FIG. 26-29. WINTER AND SUMMER RANGE OF TICK HOSTS



Sixteen of the 1274 red-backed shrikes examined yielded 19 ticks, consisting of three *Ixodes frontalis*, one *Hyalomma* sp., and 15 *H. m. marginatum*. All infested birds were from Burg El Arab, although a large number of red-backed shrikes were examined at Port Said and Mersa Matruh.

Lanius senator subsp. Woodchat. (See p. 206 and Fig. 20 of Hoogstraal et al., 1961, for range.)

The only woodchat studied, taken in September 1960, at Mersa Matruh, had lost its tail and cannot be identified to subspecies. However, the only subspecies known from Egypt in autumn is the western form *senator*, and presumably our bird is that form and came from Europe.

This bird bore one *Hyalomma* sp.

FAMILY STURNIDAE (STARLINGS)

Sturnus vulgaris tauricus Buturlin. Starling. Fig. 24.

This race of starling was called *purpurascens* by Meinertzhagen (1930). It breeds in Asia Minor and eastern and southern Ukraine, and occasionally reaches eastern Egypt in winter. Starlings were taken only in 1959, but they are seen in very considerable numbers during fall migrations. They are not caught in nets. Those visiting Egypt probably came from Asia Minor.

One of six starlings shot from a large flock near the Suez Canal was carrying a single *H. m. marginatum*.

FAMILY PLOCEIDAE (SPARROWS, WEAVERS)

Passer hispaniolensis hispaniolensis (Temminck). Spanish Sparrow. Fig. 25.

The Spanish sparrow breeds from Spain to the Balkans, in North Africa east to Cyrenaica, and possibly in Asia Minor. It is mainly resident, but large flocks winter in Egypt. Although Vaurie considers the eastern form, *transcaspicus*, to be more common in Egypt in winter, the tick hosts examined all belonged to the darker race, *hispaniolensis*, and probably came from the Balkans or Asia Minor.

In October 1960, one of five birds examined at Burg El Arab had one *Hyalomma m. marginatum*. Nine birds seen at Port Said in October 1961 were free of ticks.

FAMILY FRINGILLIDAE (FINCHES)

Fringilla coelebs coelebs Linnaeus. Chaffinch. Fig. 26.

The chaffinch breeds across much of Europe and the USSR to western Siberia, and winters in the southern part of its breeding grounds, north Africa and the Near East. It is a common winter visitor to Egypt. Birds from Scandinavia are known to winter in the British Isles; those wintering in Egypt probably come from northern USSR.

One of 10 chaffinches examined at Port Said between 2 and 4 November 1961 carried one *Hyalomma m. marginatum*.

Carduelis chloris chlorotica (Bonaparte). Greenfinch. Fig. 27.

This Near-Eastern race of greenfinch breeds from Syria to Jordan and Israel. It winters in Sinai and occasionally in the Nile Delta.

All greenfinches were taken in Port Said in November of 1959 and 1961. Two of the 159 birds each carried a single *Hyalomma m. marginatum*.

Carduelis carduelis niediecki Reichenow. Goldfinch. Fig. 28.

This Near-Eastern race of goldfinch breeds from Asia Minor to Jordan and Israel and east to western Iran. It is also found breeding near Giza, in the Nile Delta. Northern populations wander in winter and reach as far south as Egypt.

Thirty-four of these birds were examined at Port Said during the same periods recorded above for the Greenfinch. One of the 34 carried a single *Hyalomma m. marginatum*.

FAMILY EMBERIZIDAE (BUNTINGS)

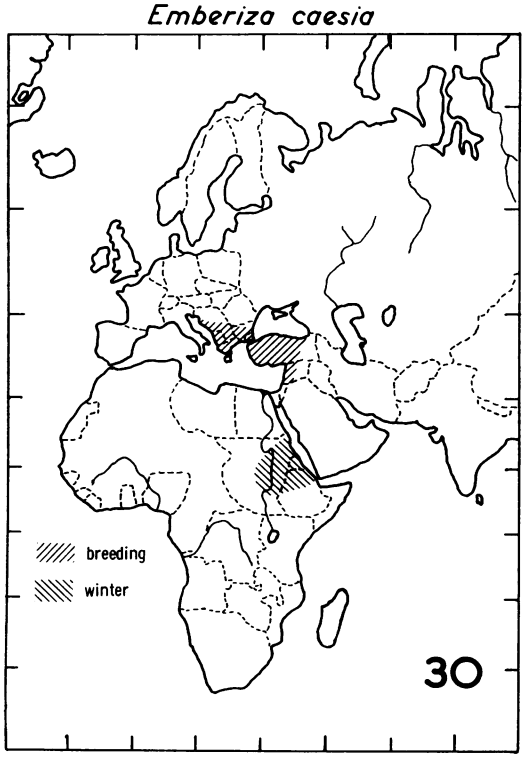
Emberiza hortulana Linnaeus. Ortolan Bunting. Fig. 29.

The ortolan bunting breeds from Europe east to Iran and central Asia, and the entire population winters in north and eastern tropical Africa. In Egypt it is rare in fall but common in spring migration. Inasmuch as the majority of these birds must move south or south-west to reach their winter quarters, Egyptian migrants may come from the USSR or from western Asia.

Two birds examined at Port Said in September 1959 were infested, as was one of two at Burg El Arab in September 1961. The ticks were four *Hyalomma m. marginatum*.

FIG. 30

WINTER AND SUMMER RANGE OF TICK HOST



Emberiza caesia Cretzschmar. Cretzschmar's Bunting. Fig. 30.

Cretzschmar's bunting breeds from the Balkans and Asia Minor to northern Israel and Jordan, and winters in the Sudan and Ethiopia. It is common on both passages in Egypt.

Three of these buntings examined at Port Said were all infested. They carried five *Hyalomma* sp., one *H. aegyptium*, and 23 *H. m. marginatum*.

NON-INFESTED BIRDS

The following 32 forms of birds, represented by 643 specimens, were never found tick-infested during the fall migration (numbers in parentheses indicate numbers examined): *Ixobrychus m. minutus* (1), *Falco v. vespertinus* (7), *Porzana porzana* (9), *Crex crex* (28), *Gallinula c. chloropus* (1), *Calidris alpina* (2), *Cursorius c. cursor* (22), *Larus r. ridibundus* (1), *Larus genei* (5), *Streptopelia* sp. (3), *Caprimulgus e. europaeus* (2), *Alcedo a. atthis* (32), *Upupa e. epops* (59), *Hirundo r. rustica* (33), *Lanius nubicus* (3), *Lanius minor* (104), *Monticola s. solitarius* (6), *Oenanthe hispanica melanoleuca* (11), *Luscinia s. svecica* (1), *Acrocephalus p. palustris* (18), *Hypolais i. icterina* (1), *Hypolais pallida elaeica* (2), *Hypolais olivitorum* (5), *Sylvia melanocephala* (2), *Ficedula p. parva* (1), *Ficedula h. hypoleuca* (1), *Emberiza c. calandra* (47), *Carduelis spinus* (95), *Acanthis cannabina mediterranea* (111), *Serinus s. serinus* (28), *Fringilla montifringilla* (1), and *Sturnus vulgaris* subsp. (1).

DISCUSSION AND CONCLUSIONS

MIGRATION ROUTES

Moreau (1961), in a most comprehensive discussion of trans-Mediterranean and trans-Saharan migration, argues cogently the theory that migration in these areas is on a broad front and not along narrow flyways. The previously-supposed concentration of birds in the Nile Valley and Delta is due to the greater number of observers and to the ease of observation rather than to an exceptional number of birds in this area. Our experience during the fall migration tends to support Moreau's thesis. Migrants arrived in great numbers on the coast at Burg El Arab just west of the Nile Delta and at Mersa Matruh some 150 miles (240 km) west of the Delta. There is no evidence of transverse migration from these localities to the Nile Delta.

Migrants reaching the coast west of the Delta were still extremely fat and appeared to be hearty enough, even after a trans-Mediterranean flight of some 300 miles (about 500 km), to make the 1000-mile (1600-km) flight across the Sahara. This is an essential physiological condition for broad-front migration. In autumn the north coast of Africa is extremely dry and inhospitable to small birds.

Since migration across the Mediterranean is on a broad front, it might be assumed that the majority of European birds migrate directly south in autumn, and that those reaching the coast of Egypt come from the western USSR. While this is undoubtedly true of some species, geographical considerations show that there must be many variations in this pattern. The bulge of western Africa extends some 500 miles (800 km) beyond the most western margin of Europe,

and birds wintering in that part of Africa must take a south-westerly course to reach their wintering grounds. Similarly, some species whose breeding range extends eastward into western Siberia winter wholly within Africa, and eastern populations of these forms must take a south-westerly course to reach their winter quarters in eastern and north-eastern Africa. On the other hand, a few species that breed throughout Europe cross the Mediterranean only at its eastern end, and any of these birds reaching Egypt will have come on a south-easterly course from western and central Europe.

In general, therefore, migrants seen on the Mediterranean coast of Egypt in autumn come from eastern Europe and from the USSR. Certain well-documented exceptions have been noted in individual species accounts above. While an attempt has been made to determine the breeding ranges of birds examined in Egypt, no banding or observational data are available for many species. For these, a generally north-south migration pattern is postulated.

The fall migration on the Egyptian coast starts during late August and quickly reaches a peak of numbers and species which gradually declines from about mid-October to mid-November.

TICK-INFESTATION OF MIGRANTS

Data for tick-infested fall migrants in Egypt, summarized in Table 2, should be compared with those for spring migrants in Egypt (see Tables 1 and 2 in Hoogstraal et al., 1961). The migration patterns and routes of many host species differ considerably in the spring and fall. Therefore, bird species and subspecies captured, even by utilizing several techniques in various localities, partially differ in each season. The incidence and rates of tick infestation also differ for many host forms and, of course, the tick species transported are totally different. A number of tick species with adult or immature-stage host predilection for birds occur in the geographical areas and in many of the ecological biotopes visited by these birds during both seasons. One of the most critical factors influencing parasitism of migrant birds is the coincidence in any given area of their presence with the period of feeding activity of the tick species available to parasitize them. Furthermore, it is entirely possible that one or more tick species may feed on a bird while it is settled in its winter or summer quarters and yet may not be represented in collections made during migration because of seasonal periodicity of feeding habits. Such factors may, of course, subtly influence the range of pathogens available to both the host and its parasites.

During the spring migration (1956-60), 22 forms of birds were found to be tick-infested in Egypt; during the fall migration 40 forms yielded ticks. Sixteen bird forms in the spring of 1960 were uninfested while 33 during the three fall migrations were uninfested.

Almost 300 forms of birds migrate through Egypt in varying numbers, therefore the available data merely serve to suggest the magnitude and diversity of the problem rather than to provide a precise picture of infestation patterns as they actually occur in nature. Some of the most common migrants are impossible to obtain alive in large numbers, or do not settle in one or any of the localities being investigated. Comparison of the data presented in Appendix Tables 1, 2, and 3 with the total summary in Table 2 provides a lucid illustration of similarities and of differences obtained during the same periods of different years.

TICKS SPECIES AND THEIR HOSTS

One of us (H. H.) is preparing a monographic study on bird, ectoparasite, and disease dissemination interrelationships in which the tick species (and bird hosts) recorded here will be fully reviewed. These parasites, therefore, are only briefly discussed below. The complete data for ticks taken during this study appear in Table 2.

Ixodes larvae and nymphs were very difficult to determine to species, and imperfect specimens as well as those turned over alive to the NAMRU-3 Virology Department in 1961 were identified as *Ixodes* sp. We are grateful to Dr Carleton Clifford of the Rocky Mountain Laboratory for the final determinations of *Ixodes frontalis* and *I. ricinus*. Altogether 150 ticks, 8.52% of the total collections, were identified as *Ixodes* sp.

Ixodes frontalis (Panzer, 1798) is widely distributed from the British Isles across Europe and temperate Asia to Japan. This tick is probably rather more common in many areas of its extensive geographical range than present meagre records indicate. Larvae, nymphs and females infest birds, and so far as is known parasitize no other vertebrates. Males, which presumably feed briefly if at all, might be found in nests or where birds feed; these details remain to be studied. Hosts of predilection cannot yet be recog-

nized from available data. The host range is apparently extensive among birds.

I. frontalis, which accounted for 2.61% of the ticks collected, was represented by 43 larvae and nymphs and three females, from *Coturnix c. coturnix* (4), *Saxicola torquata rubicola* (1), *Sylvia c. communis* (1), *Phylloscopus trochilus* subspp. (33), *Phylloscopus c. collybita* (1), *Muscicapa s. striata* (3), and *Lanius c. collurio* (3). Some specimens identified as *Ixodes* sp. undoubtedly include *I. frontalis*.

Ixodes ricinus (Linnaeus, 1758) occurs in much of Europe and in south-western USSR, parts of north-western Africa, and Asia Minor (see Fig. 3 in Smorodintsev, 1958). An ecologically versatile tick, *I. ricinus* occurs in a variety of forest and pasture situations. Adults parasitize domestic animals and also wild elk, hares, carnivores and hedgehogs. Immature stages feed on numerous rodents, hares, carnivores and birds. Birds are considered by European and Soviet workers to be important agents for introducing this species into new or already infested areas.

Probably many specimens identified as *Ixodes* sp. from migrating birds in Egypt were actually *I. ricinus*. Ticks definitely identified as *I. ricinus* numbered 183, 10.39% of the total collections. They were taken from *Coturnix c. coturnix* (2), *Oriolus o. oriolus* (2), *Saxicola r. rubetra* (1), *Luscinia luscinia* (104), *Luscinia m. megarhynchos* (34), *Sylvia c. communis* (12), *Sylvia c. curruca* (1), *Phylloscopus trochilus* subspp. (20), and *Anthus c. campestris* (7).

Haemaphysalis punctata Canestrini and Fanzago, 1878, is also widely distributed, from Central Asia through southern USSR and Europe to Algeria. Adults feed on all domestic animals. Immature stages most frequently parasitize many kinds of ground-feeding birds, less commonly small rodents, hares, and carnivores, as well as lizards.

H. punctata was represented in these collections by 495 larvae and nymphs, comprising 28.11% of the total ticks taken. Four hundred and sixteen (84%) of these were from *Coturnix c. coturnix*, others from *Saxicola r. rubetra* (3), *Oenanthe o. oenanthe* (3), *Oenanthe* sp. (1), *Phoenicurus p. phoenicurus* (7), *Luscinia luscinia* (7), *Luscinia m. megarhynchos* (2), *Acrocephalus schoenobaenus* (7), *Phylloscopus trochilus* subspp. (27), *Muscicapa s. striata* (9), *Anthus c. campestris* (1), and *Anthus t. trivialis* (12).

Haemaphysalis pavlovskyi Pospelova-Shtrom, 1935, a poorly known species, has been reported from pheasants and hares in tugai forest of southern Tadzhikistan. A male of this species was found in a Bedouin's quail-holding bag near Mersa Matruh in September 1960. One nymph was collected from *Coturnix c. coturnix* (Burg El Arab, September 1961) and two larvae from *Phylloscopus trochilus* subspp. (Port Said, October 1961). These are new host records for *H. pavlovskyi*. Attempts to rear these immature stages to adults were unsuccessful. Soviet workers are not known to have described the larval stage of *H. pavlovskyi* and have not replied to queries in letters from us (H. H.) enclosing figures of larvae referred to here as *H. pavlovskyi*. These larvae, however, are like no others already described from the geographical area in which their hosts originated (eastern Europe or western USSR). They conform to group characteristics of the *H. doenitzi-hoodi* complex, of which *H. pavlovskyi* is a member. We therefore tentatively consider these larvae as *H. pavlovskyi*, especially since a male and nymph of this species were also taken.

Haemaphysalis sulcata Canestrini and Fanzago, 1878, is common in southern USSR from Central Asia westward, and occurs in southern Europe, from Iran to Sinai, and in Arabia south to Yemen and the Aden Protectorate. Adults feed on wild and domestic sheep and goats and on other domestic animals. Immature stages appear to prefer lizards, but also feed on birds and small mammals. Single specimens of *H. sulcata* were taken from *Oenanthe o. oenanthe*, *O. isabellina*, *Luscinia luscinia*, and *Motacilla flava*.

Haemaphysalis otophila Schulze, 1918, ranges from the Ukraine and Daghestan through Asia Minor and the Balkans to southern Europe and Libya. Adults parazitize domestic animals; immature stages feed chiefly on small mammals but also on birds and lizards. Two specimens of *H. otophila* were found on *Coturnix c. coturnix*.

Hyalomma spp. includes larvae and nymphs too damaged to identify to species. Immature stages of *Hyalomma* ticks are very difficult to identify to species, even under the best of conditions. Undoubtedly most or all of these 116 specimens, 6.60% of the total tick collection, were either *H. aegyptium* or *H. m. marginatum*.

Hyalomma aegyptium (Linnaeus, 1758) is distributed in Tadzhikistan and westward in southern USSR, from Afghanistan to Lebanon and the Balkans, and in the Mediterranean area of Europe and north-western Africa. All stages feed primarily on tortoises (*Testudo*). Rarely, adults feed on hedgehogs and other mammals. Immature stages also

TABLE 2

TICKS FROM AUTUMN MIGRATORY BIRDS IN EGYPT, 1959-61

Bird hosts				Immature ticks											
Species	No. examined	Infested		*Ixodes*			*Haemaphysalis*				*Hyalomma*			Total ticks	No. ticks per host
		No.	%	sp.	*frontalis*	*ricinus*	*punctata*	*sulcata*	*otophila*	*pavlovskyi*	sp.	*aegyptium*	*m. marginatum*		
Falco naumanni	1	1	100.00	0	0	0	0	0	0	0	1	0	0	1	1.00
Coturnix c. coturnix	16 061	491 [a]	3.05	10	4	2	416	0	2	1	11	63	136	645	1.31
Streptopelia t. turtur [b]	1 237	3	0.24	1	0	0	0	0	0	0	0	2	1	4	1.33
Cuculus canorus canorus	47	2	4.25	3	0	0	0	0	0	0	0	0	1	4	2.00
Otus s. scops	5	3	60.00	0	0	0	0	0	0	0	0	0	10	10	3.33
Merops apiaster	5	1	20.00	0	0	0	0	0	0	0	0	0	1	1	1.00
Coracias g. garrulus	53	1	1.88	0	0	0	0	0	0	0	1	0	0	1	1.00
Jynx t. torquilla	43	1	2.32	0	0	0	0	0	0	0	3	0	0	3	3.00
Oriolus o. oriolus	466	11	2.36	0	0	2	0	0	0	0	2	0	15	19	1.72
Saxicola r. rubetra	506	17	3.35	0	0	1	3	0	0	0	12	0	12	28	1.64
Saxicola torquata rubicola	7	2	28.57	0	1	0	0	0	0	0	0	0	1	2	1.00
Oenanthe o. oenanthe	226	10	4.42	0	0	0	3	1	0	0	6	1	14	25	2.50
Oenanthe isabellina	116	5	4.31	0	0	0	0	1	0	0	4	1	1	8	1.60
Oenanthe sp.[c]	55	2	3.63	0	0	0	1	0	0	0	2	0	0	3	1.50
Monticola saxatilis	10	2	20.00	0	0	0	0	0	0	0	0	0	13	13	6.50
Phoenicurus p. phoenicurus	1 253	84	6.70	13	0	0	7	0	0	0	1	2	109	132	1.57
Luscinia luscinia	287	70	24.40	24	0	104	7	1	0	0	3	0	16	155	2.21
Luscinia m. megarhynchos	141	18	12.74	5	0	34	2	0	0	0	1	0	9	51	2.83
Luscinia sp.[c]	50	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0.00
Acrocephalus schoenobaenus	138	1	0.72	0	0	0	7	0	0	0	0	0	0	7	7.00
Sylvia b. borin	166	3	1.80	0	0	0	0	0	0	0	0	0	3	3	1.00
Sylvia a. atricapella	18	1	5.55	0	0	0	0	0	0	0	0	0	2	2	2.00

Sylvia c. communis	1 134	5	0.44	2	1	12	0	0	0	0	1	0	2	18	3.60
Sylvia c. curruca	904	4	0.44	0	0	1	0	0	0	0	0	0	4	5	1.25
Phylloscopus trochilus subspp.[d]	6 283	226	3.60	87	33	20	27	0	0	2	53	4	180	416	1.84
Phylloscopus c. collybita	1	1	100.00	0	1	0	0	0	0	0	0	0	1	2	2.00
Ficedula a. albicollis	8	2	25.00	0	0	0	0	0	0	0	2	0	1	3	1.50
Muscicapa s. striata	590	24	4.06	3	3	0	9	0	0	0	1	0	19	35	1.45
Anthus c. campestris	18	9	50.00	2	0	7	1	0	0	0	3	0	16	29	3.22
Anthus t. trivialis	56	9	16.06	0	0	0	12	0	0	0	2	1	69	84	9.33
Motacilla flava subsp.	1	1	100.00	0	0	0	0	1	0	0	0	0	1	2	2.00
Motacilla a. alba	43	1	2.32	0	0	0	0	0	0	0	0	0	1	1	1.00
Lanius c. collurio	1 274	16	1.24	0	3	0	0	0	0	0	1	0	15	19	1.18
Lanius senator subsp.	1	1	100.00	0	0	0	0	0	0	0	1	0	0	1	1.00
Sturnus vulgaris tauricus	6	1	16.66	0	0	0	0	0	0	0	0	0	1	1	1.00
Passer h. hispaniolensis	14	1	7.14	0	0	0	0	0	0	0	0	0	1	1	1.00
Fringilla c. coelebs	10	1	10.00	0	0	0	0	0	0	0	0	0	1	1	1.00
Carduelis chloris chlorotica	159	2	1.25	0	0	0	0	0	0	0	0	0	2	2	1.00
Carduelis carduelis niediecki	34	1	2.94	0	0	0	0	0	0	0	0	0	1	1	1.00
Emberiza hortulana	4	3	75.00	0	0	0	0	0	0	0	0	0	4	4	1.33
Emberiza caesia	3	3	100.00	0	0	0	0	0	0	0	5	1	23	29	9.66
Collecting bag	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—
Total (40 host forms and collecting bag)[e]	31 434	1 040		150	46[f]	183	495	4	2	4	116	75	686	1 761	1.69
Percentage of total		3.31		8.52	2.61	10.39	28.11	0.22	0.11	0.22	6.60	4.26	38.96		

[a] Numerous ticks were lost from quail.

[b] *Streptopelia turtur* consists of subspecies *turtur* and *arenicola*; only *turtur* was infested.

[c] *Oenanthe* sp. and *Luscinia* sp. consist of the two forms noted. See text and Appendix Table 1 for reasons for including non-infested *Luscinia* sp. here.

[d] *Phylloscopus trochilus* consists of subspecies *trochilus* and *acredula*.

[e] In addition, 652 birds representing 33 other species were also examined and found free of ticks.

[f] *Ixodes frontalis* total 3 females and 43 larvae and nymphs.

infest lizards, birds, rodents and hares. The 75 *H. aegyptium* larvae and nymphs comprise 4.26% of the total ticks collected. They were parasitizing *Coturnix c. coturnix* (63), *Streptopelia t. turtur* (2), *Oenanthe o. oenanthe* (1), *O. isabellina* (1), *Phoenicurus p. phoenicurus* (2), *Phylloscopus trochilus* subspp. (4), *Anthus t. trivialis* (1), and *Emberiza caesia* (1). Presumably some specimens identified as *Hyalomma* spp. were actually *H. aegyptium.*

Hyalomma m. marginatum Koch, 1844, which Soviet workers call *H. p. plumbeum* (Panzer, 1795), is common in south-western USSR, in the Ukraine, Crimea, the Caucasus and western Transcaucasia, and the lower Volga (Astrakhan), and also occurs in southern Europe and north-western Africa. Significantly, we have collected typical adults of this tick in the Sudan and have seen others from Kenya. There are, in addition, numerous records in the literature of isolated specimens collected and of small populations established to the north of the normal range of *H. m. marginatum.* Adult hosts are chiefly domestic animals, but also include hares and the larger birds. Larvae and nymphs parasitize birds and hares. Presumably approximately a hundred of the 116 ticks listed in Table 2 as *Hyalomma* spp. are actually *H. m. marginatum.*

All adult specimens reared from *marginatum* larvae and nymphs were typical of the subspecies *marginatum* in primary diagnostic characters, but between 10% and 20% of them were suggestive of the subspecies *turanicum* Pomerantzev, 1946, in secondary characters and probably represent intergrades from marginal geographical areas or ecological zones. The subspecies *turanicum* occurs chiefly in southern Kazakhstan, Central Asia and Iran, but smaller populations are widely distributed through the Near East. After years of intensive study of a tremendous amount of material in this complex (H. H. and M. N. K.), we have not yet reached final conclusions concerning the exact relationships of the subspecies *marginatum* and *turanicum.* Their immature stages most probably cannot be differentiated. Interbreeding between the subspecies *marginatum, rufipes,* and *turanicum* possibly occurs in some areas as a result of introductions by migrating birds.

The 686 larvae and nymphs of *H. m. marginatum,* a parasite of outstanding medical and veterinary importance, made up 38.96% of the total ticks taken and occurred on 35 of the 40 kinds of birds found tick-infested during the period of this study. Most specimens were taken from *Coturnix c. coturnix, Phylloscopus trochilus* subspp., *Phoenicurus p. phoenicurus, Anthus t. trivialis,* and *Emberiza caesia.* For other hosts and rates of infestation see Table 2.

In summary, of the ticks collected in 1959, 1960 and 1961 in Egypt from fall migrants, 1761 ticks were taken from 1040 birds of 40 forms. A total of 31 434 birds of these same forms was scrutinized for ticks. The prevalence of infestation of the bird forms found infested was 3.31% and the rate of infestation was 1.69 ticks per bird. An additional 32 forms of birds, represented by 643 individuals, were examined and found to be entirely free of ticks. Thus, a total of 32 086 birds representing 72 forms was investigated. The most common tick species were *Hyalomma m. marginatum* on 35 host forms, *Ixodes ricinus* on nine host forms, and *Haemaphysalis punctata* on 12 host forms. *Haemaphysalis sulcata, H. otophila,* and *H. pavlovskyi* were rare, and *Hyalomma aegyptium* and *Ixodes frontalis* were uncommon. The host list for each tick species provides important biological and epidemiological clues. However, it is probably unsafe to attempt precise conclusions concerning the relative significance of each host species on the basis of the comparatively limited and localized data available at this time.

Moreau (1961) estimates that 600 000 000 birds migrate into Africa each year from Europe west of 34°E. The prevalence and rate of tick infestation found in Egypt suggest the enormous numbers of ticks that must be carried into this continent annually.

TICK, BIRD AND PATHOGEN INTERRELATIONSHIPS

Ixodes frontalis feeds in all developmental stages on birds only and might be responsible for a bird-tick-bird cycle of pathogen dissemination in nature. Different tick or arthropod species perhaps imbibe, maintain and transfer pathogens from infected birds to other vertebrates. *Rickettsia burnetii,* causing Q fever, has been isolated from *I. frontalis* from a rookery in the USSR. *Haemaphysalis pavlovskyi* falls in a similar category except that hares are also nymphal hosts, though probably less frequently than birds. Thus the pathogen dissemination potential of this species may be somewhat enhanced. *Hyalomma aegyptium* is also largely restricted to wild vertebrate hosts; while these are chiefly tortoises, also infested with some degree of frequency are lizards, birds and mammals. Experimentally, *H. aegyptium* has been shown to be a reservoir of Q fever (*Rickettsia burnetii*).

The remaining five tick species from fall migrants in Egypt, all known as reservoirs and disseminators of human and animal pathogens, differ from the above three in that their immature stages feed on a variety of birds and small mammals and their adults parasitize large domestic and some wild animals. Larvae, nymphs and adults of these species sometimes feed on humans and in so doing may transmit pathogens directly from wild animal reservoirs to man. Their actual or potential role in maintaining foci of infection in the native fauna is, however, a more important epidemiological consideration. Unfortunately, this factor is often lightly regarded in studies of disease dissemination. Different tick and other arthropod species and airborne, contact or other routes of infection may be responsible for conveying the pathogenic organisms from a wild or domestic animal focus to humans.

In this geographical area—western and central Asia, southern Europe and Africa—tick-borne diseases of domestic animals are exceptionally numerous and common. From the medical point of view, the reduction in available meat supplies, with consequent lower nutritional and disease-resistance levels in man, is therefore also worthy of serious consideration. Each of the tick species discussed below figures prominently in this respect.

Ixodes ricinus is an important reservoir and vector of the viral agents of Russian spring-summer encephalitis, biphasic meningo-encephalitis (of central Europe, Sweden and parts of the Balkans), and of louping-ill. This species is suspect as the vector of the virus causing haemorrhagic fever in northern Bukovina (adjacent to northern Romania). Specimens infected with the virus causing lymphocytic choriomeningitis have been found in the southern Ukraine. Experimentally, *I. ricinus* has been shown to be a vector of a Japanese mosquito-borne encephalitis-causing virus. This tick has been incriminated in the epidemiology of infectious nephrosonephritis (*Rickettsia pavlovskii*) in the USSR as well as of tick paroxysmal rickettsiosis (*Wolhynia rutchkovskii*) in the Ukraine and of Q fever (*Rickettsia burnetii*) in Europe and the USSR. The *Rickettsia* causing Indian tick typhus (probably identical with boutonneuse fever, *Rickettsia conorii*) has been isolated from ticks identified as *I. ricinus* in the Kumaon Hills of northern India. *I. ricinus* is also a reservoir and vector of tularaemia (*Pasteurella tularensis*). Persons bitten by *I. ricinus* sometimes suffer severe toxic effects.

As to diseases restricted entirely to domestic animals, *I. ricinus* is a vector of tick-borne fever of ruminants in Great Britain and Norway caused by "*Rickettsia*" (probably *Erlichia*) *phagocytophila*. It is also a vector of bovine babiosis (*Babesia bovis*) and of malignant bovine anaplasmosis (*Anaplasma marginale*), both in Europe, and causes tick paralysis of sheep and goats in Crete.

The role of birds in transporting *I. ricinus* infected with the virus of Russian spring-summer encephalitis intracontinentally over great distances has often been stressed by European and Soviet workers.

Hyalomma m. marginatum is the primary vector of the virus causing Crimean haemorrhagic fever, a human disease still unsatisfactorily elucidated epidemiologically. It is also a vector of *Rickettsia burnetii* (Q fever) and transmits the organism from one generation to the next transovarially. This tick has also been more or less conclusively incriminated in the epidemiology of brucellosis (*Brucella melitensis*), tularaemia (*Pasteurella tularensis*) and other epizootic diseases. Among animal diseases, it is the vector of *Gonderia* (= *Theileria*) *annulata* and *G.* (= *T.*) *mutans* of cattle, and of other protozoal infections of horses. It has also been found infected with an unnamed *Rickettsia* pathogenic for guinea-pigs and transmitted transovarially to the third generation of the tick. Persons bitten by *H. m. marginatum* may experience acute but temporary toxicosis.

Haemaphysalis punctata is regarded by Soviet and other workers as a possible vector of *Rickettsia conorii* (tick typhus or boutonneuse fever) in Crimea, of *Pasteurella tularensis* (tularaemia), of *Brucella melitensis* (brucellosis), and of *Rickettsia* (*Dermacentroxenus*) *siberica* (Siberian tick typhus). It transmits *Babesia* spp. of sheep, goats, and swine, *Anaplasma marginale*, *A. centrale*, and *Babesia bigemina* of cattle, and causes paralysis of calves, goats, sheep, and humans.

Haemaphysalis sulcata transmits *Brucella melitensis*, *Anaplasma ovis* and *Gonderia ovis*, and causes paralysis in animals. *H. otophila* has been incriminated in transmission of *Babesia ovis*.

Many forms of bird hosts examined in Egypt have been reported by European and Soviet workers to be reservoirs of pathogenic organisms. This literature will be reviewed in a subsequent paper (H. H.).

The epidemiological role of the tick species reported here, both as reservoirs and as vectors of many human and veterinary diseases, remains poorly studied and knowledge is particularly weak in the area of viral and rickettsial agents.

Ticks, for a number of reasons, function more effectively as reservoirs of certain pathogenic ecosystems than many highly organized ectoparasites and vertebrates (Philip & Burgdorfer, 1961; Philip, 1962). Recent findings of chronic, long-term viral infections in vertebrates (Reeves, 1961) and the wide host range in which arthropod-borne viruses may survive and multiply (Hurlbut & Thomas, 1960) illustrate fast-changing epidemiological concepts that must be investigated in relation to the disease-disseminating role of migrating birds and their ectoparasites. Reinforcing this need, several well-documented, fresh extensions of previously known geographical ranges of bird and other vertebrate species demonstrate that nature is not static. The potential of pathogens to spread from their normal geographical and host range is equally real. Kyasanur Forest disease (related to Omsk haemorrhagic fever) a previously unknown tick-borne affliction of monkeys and humans, recently appeared in India in epidemic proportions (Work, 1958). In both North and South America, mosquito-transmitted, encephalitis-causing viruses harboured in birds are frequently found hundreds or thousands of miles from their nearest previously known focus. These discoveries and phenomena clearly show the need for imaginative thinking and research in the patterns and details of disease dissemination.

RÉSUMÉ

Dans un article publié en 1961 dans le Bulletin de l'OMS, les auteurs avaient présenté les résultats de leurs recherches sur les tiques infestant les oiseaux migrateurs examinés en Egypte pendant la migration de printemps, de l'Afrique vers l'Europe orientale et l'Asie. Dans le présent travail, ils rapportent des observations faites au moment de la migration d'automne en 1959, 1960 et 1961.

Durant cette période ont été examinés 32 086 oiseaux appartenant à 72 variétés différentes. Trente-deux de ces variétés ne sont jamais infestées par les tiques, comme l'a montré l'examen de 643 animaux. Par contre, 40 variétés sont susceptibles d'être infestées. Trente et un mille quatre cent trente quatre oiseaux appartenant à ces variétés ont été minutieusement examinés et on a trouvé une ou plusieurs tiques sur 1040 (3,31 %) d'entre eux. Le total des tiques prélevées s'étant élevé à 1761, le nombre moyen de tiques par oiseau est de 1,69. Les oiseaux parasités sont de toutes sortes: faucons, cailles, faisans, pigeons, tourterelles, coucous, chouettes, geais, torcols, loriots, grives, tariers, fauvettes, gobe-mouches, bergeronnettes, farlouses, pies-grièches, étourneaux, hirondelles, pinsons, bruants.

Parmi les tiques prélevées sur ces oiseaux, les plus communes sont: *Hyalomma m. marginatum*, *Haemaphysalis punctata* et *Ixodes ricinus*. *Ixodes frontalis* et *Hyalomma aegyptium* sont d'observation moins fréquente. Quant à *Haemaphysalis sulcata*, *H. orophila* et *H. pavlovskyi*, elles sont vraiment rares.

L'ampleur du problème apparaît immédiatement si l'on songe que l'on estime à 600 000 000 le nombre d'oiseaux qui migrent d'Europe orientale vers l'Afrique.

Parmi les tiques étudiées, trois peuvent accomplir leur cycle biologique entier sur l'oiseau: ce sont *Ixodes frontalis* sur laquelle *Rickettsia burnetii*, la rickettsie responsable de la fièvre Q, a été isolée, *Haemaphysalis pavlovskyi* et *Hyalomma aegyptium* qui, au laboratoire, s'est montrée un bon réservoir de *Rickettsia burnetii*. Les cinq autres genres de tiques ne vivent sur les oiseaux que les premiers stades de leur existence, et vont ensuite parasiter des grands animaux domestiques ou sauvages. Ils peuvent donc jouer un rôle important dans la persistance de foyers d'infestation. *Ixodes ricinus* est un important réservoir et vecteur du virus de l'encéphalite du printemps et de l'été en Russie, de la méningo-encéphalite récurrente et de l'encéphalomyélite ovine. Son rôle de vecteur est également probable dans l'éclosion d'épidémies de néphrite-néphrose infectieuse en URSS (*Rickettsia pavlovskyi*), de rickettsiose paroxystique en Ukraine (*Wolhynia rutchovskii*), de fièvre Q en Europe et en URSS, de fièvre boutonneuse (*Rickettsia conorii*), de tularémie (*Pasteurella tularensis*). *Hyalomma m. marginatum* est l'animal vecteur de la fièvre hémorragique de Crimée et peut transmettre la fièvre Q, ainsi que différentes affections du bétail. *H. punctata* est considérée par les auteurs soviétiques comme vecteur possible de la fièvre boutonneuse en Crimée, de la tularémie, de la brucellose et du typhus sibérien à tiques, ainsi que de certaines viroses paralysant veaux, chèvres et moutons. *H. sulcata* transmet *B. melitensis* et certaines viroses paralytiques de l'animal. *H. otophila* a été incriminée dans la transmission de *Babesia ovis* du mouton.

Tous ces faits expliquent la dissémination à des centaines ou des milliers de kilomètres de certaines épidémies d'abord très localisées.

APPENDIX TABLE 1
TICK-INFESTED AUTUMN MIGRATORY BIRDS IN EGYPT, 1959

Bird hosts				Immature ticks									
Species	No. examined	Infested		*Ixodes*			*Haemaphysalis*		*Hyalomma*			Total ticks	No. ticks per host
		No.	%	sp.	*frontalis*	*ricinus*	*punctata*	*sulcata*	sp.	*aegyptium*	*m. marginatum*		
Coturnix c. coturnix	4 431	125	2.82 [a]	2	0	0	62	0	3	14	34	115	>1.0 [a]
Cuculus c. canorus	20	1	5.00	0	0	0	0	0	0	0	1	1	1.0
Merops apiaster	4	1	2.50	0	0	0	0	0	0	0	1	1	1.0
Coracias g. garrulus	36	1	2.77	0	0	0	0	0	1	0	0	1	1.0
Jynx t. torquilla	12	1	8.33	0	0	0	0	0	3	0	0	3	3.0
Oriolus o. oriolus	102	3	2.94	0	0	0	0	0	0	0	3	3	1.0
Saxicola r. rubetra	217	9	4.14	0	0	1	3	0	12	0	0	16	1.7
Oenanthe o. oenanthe	112	4	3.57	0	0	0	1	1	2	0	8	12	3.0
Oenanthe isabellina	50	2	4.00	0	0	0	0	0	2	1	0	3	1.5
Oenanthe sp.	55	2	1.16	0	0	0	1	0	2	0	0	3	1.5
Monticola saxatilis	2	1	50.00	0	0	0	0	0	0	0	10	10	10.0
Phoenicurus p. phoenicurus	322	27	8.38	12	0	0	0	0	0	1	34	47	1.7
Luscinia luscinia	62	9	19.35	10	0	9	1	0	0	0	2	22	2.4
Luscinia m. megarhynchos		3		0	0	1	1	0	0	0	1	3	1.0
Sylvia c. communis	227	3	1.32	2	1	11	0	0	1	0	0	15	5.0
Phylloscopus trochilus subspp. [b]	1 127	96	8.51	0	33	1	2	0	30	1	87	154	1.6
Phylloscopus collybita	1	1	100.00	0	1	0	0	0	0	0	1	2	2.0
Muscicapa s. striata	99	8	8.08	0	2	0	1	0	0	0	8	11	1.3
Anthus c. campestris	3	3	100.00	0	0	0	0	0	3	0	6	9	3.0
Anthus t. trivialis	30	5	16.66	0	0	0	12	0	0	1	18	31	6.2
Motacilla flava subsp.	1	1	100.00	0	0	0	0	1	0	0	1	2	2.0
Lanius c. collurio	411	7	1.21	0	2	0	0	0	1	0	5	8	1.1
Sturnus vulgaris tauricus	6	1	16.66	0	0	0	0	0	0	0	1	1	1.0
Carduelis chloris chlorotica	35	1	2.85	0	0	0	0	0	0	0	1	1	1.0
Carduelis carduelis niediecki	11	1	9.09	0	0	0	0	0	0	0	1	1	1.0
Emberiza hortulana	2	2	100.00	0	0	0	0	0	0	0	3	3	1.5
Emberiza caesia	3	3	100.00	0	0	0	0	0	5	1	23	29	9.7
Total (28 host forms) [c]	7 429	321		26	39	23	84	2	65	19	249	507	1.57

[a] Owing to techniques used in handling infested quail in 1959, numerous ticks were lost.
[b] *Phylloscopus trochilus* consists of subspecies *trochilus* and *acredula*.
[c] In addition, 998 birds representing 23 other species were also examined and found free of ticks.

APPENDIX TABLE 2

TICK-INFESTED AUTUMN MIGRATORY BIRDS IN EGYPT, 1960

Bird hosts				Immature ticks										
Species	No. examined	Infested		*Ixodes*		*Haemaphysalis*				*Hyalomma*			Total ticks	No. ticks per host
		No.	%	*frontalis*	*ricinus*	*punctata*	*sulcata*	*otophila*	*pavlovskyi*	sp.	*aegyptium*	*m. marginatum*		
Falco naumanni	1	1	100.00	0	0	0	0	0	0	1	0	0	1	1.0
Coturnix c. coturnix	4 190	203	4.84	3 [a]	0	221	0	2	0	8	27	53	314	1.5
Otus s. scops	1	1	100.00	0	0	0	0	0	0	0	0	1	1	1.0
Oriolus o. oriolus	258	8	3.10	0	2	0	0	0	0	2	0	12	16	2.0
Oenanthe o. oenanthe	60	6	10.00	0	0	2	0	0	0	4	1	6	13	2.1
Oenanthe isabellina	59	3	3.38	0	0	0	1	0	0	2	0	1	4	1.3
Monticola saxatilis	1	1	100.00	0	0	0	0	0	0	0	0	3	3	3.0
Phoenicurus p. phoenicurus	226	14	6.19	0	0	3	0	0	0	1	0	12	16	1.1
Luscinia luscinia	132	27	20.45	0	48	3	1	0	0	3	0	0	55	2.0
Luscinia m. megarhynchos	87	3	3.44	0	20	0	0	0	0	1	0	4	25	8.3
Sylvia b. borin	61	2	3.27	0	0	0	0	0	0	0	0	2	2	1.0
Sylvia c. communis	389	1	0.25	0	1	0	0	0	0	0	0	0	1	1.0
Sylvia c. curruca	149	1	0.67	0	1	0	0	0	0	0	0	1	2	2.0
Phylloscopus trochilus subspp.[b]	1 084	37	3.41	0	12	6	0	0	0	8	1	35	62	1.6
Ficedula a. albicollis	6	1	16.66	0	0	0	0	0	0	2	0	0	2	2.0
Muscicapa s. striata	167	10	5.98	1	0	6	0	0	0	1	0	4	12	1.2
Anthus c. campestris	10	2	20.00	0	0	0	0	0	0	0	0	2	2	1.0
Anthus t. trivialis	1	1	100.00	0	0	0	0	0	0	2	0	40	42	42.0
Lanius c. collurio	325	1	0.30	1	0	0	0	0	0	0	0	0	1	1.0
Lanius senator subsp.	1	1	100.00	0	0	0	0	0	0	1	0	0	1	1.0
Passer h. hispaniolensis	5	1	20.00	0	0	0	0	0	0	0	0	1	1	1.0
Collecting bag	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Total (22 host forms and collecting bag) [c]	7 311	325		5	84	241	2	2	1	36	29	177	577	1.77

[a] Two immature and one adult female *Ixodes frontalis*.

[b] *Phylloscopus trochilus* consists of subspecies *trochilus* and *acredula*.

[c] In addition, 502 birds representing 22 other species were also examined and found free of ticks.

APPENDIX TABLE 3
TICK-INFESTED AUTUMN MIGRATORY BIRDS IN EGYPT, 1961

Bird hosts				Immature ticks									
Species	No. examined	Infested		*Ixodes*			*Haemaphysalis*		*Hyalomma*			Total ticks	No. ticks per host
		No.	%	sp.	*frontalis*	*ricinus*	*punctata*	*pavlovskyi*	sp.	*aegyptium*	*m. marginatum*		
Coturnix c. coturnix	7 440	163[a]	2.10	8	1[b]	2	133	1	0	22	49	216	1.3
Streptopelia t. turtur[c]	450	3	0.60	1	0	0	0	0	0	2	1	4	3.3
Cuculus c. canorus	3	1	33.33	3	0	0	0	0	0	0	0	3	3.0
Otus s. scops	3	2	66.66	0	0	0	0	0	0	0	9	9	4.5
Saxicola r. rubetra	231	8	3.46	0	0	0	0	0	0	0	12	12	1.5
Saxicola torquata rubicola	7	2	28.57	0	1[b]	0	0	0	0	0	1	2	1.0
Phoenicurus p. phoenicurus	705	43	6.00	1	0	0	4	0	0	1	63	69	1.6
Luscinia luscinia	146	34	23.28	14	0	47	3	0	0	0	14	78	2.3
Luscinia m. megarhynchos	51	12	23.52	5	0	13	1	0	0	0	4	23	1.9
Acrocephalus schoenobaenus	63	1	1.58	0	0	0	7	0	0	0	0	7	7.0
Sylvia b. borin	72	1	1.38	0	0	0	0	0	0	0	1	1	1.0
Sylvia a. atricapella	13	1	7.69	0	0	0	0	0	0	0	2	2	2.0
Sylvia c. communis	518	1	0.19	0	0	0	0	0	0	0	2	2	2.0
Sylvia c. curruca	416	3	0.72	0	0	0	0	0	0	0	3	3	1.0
Phylloscopus trochilus subspp.[d]	4 072	93	2.28	87	0	7	19	2	15	2	58	190	2.0
Ficedula a. albicollis	2	1	50.00	0	0	0	0	0	0	0	1	1	1.0
Muscicapa s. striata	324	6	1.80	3	0	0	2	0	0	0	7	12	2.0
Anthus c. campestris	5	4	80.00	2	0	7	1	0	0	0	8	18	4.5
Anthus t. trivialis	25	3	12.00	0	0	0	0	0	0	0	11	11	3.6
Motacilla a. alba	9	1	11.11	0	0	0	0	0	0	0	1	1	1.0
Lanius c. collurio	538	8	1.48	0	0	0	0	0	0	0	10	10	1.2
Fringilla c. coelebs	10	1	10.00	0	0	0	0	0	0	0	1	1	1.0
Carduelis chloris chlorotica	124	1	0.80	0	0	0	0	0	0	0	1	1	1.0
Emberiza hortulana	2	1	50.00	0	0	0	0	0	0	0	1	1	1.0
Total (25 host forms)[e]	15 225	394		124	2[b]	76	170	3	15	27	260	677	1.71

[a] Ticks seen on 163 quail in field; ticks recovered from 150 of these in laboratory.
[b] One adult female *Ixodes frontalis* from each host species included in these figures.
[c] *Streptopelia turtur* consists of subspecies *turtur* and *arenicola*; only *turtur* was infested.
[d] *Phylloscopus trochilus* consists of subspecies *trochilis* and *acredula*.
[e] In addition, 822 birds representing 23 other species were also examined and found free of ticks.

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